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Management of ice storm damaged woodlots and plantations.

ONTARIO MINISTRY OF NATURAL RESOURCES
SCIENCE DEVELOPMENT AND TRANSFER
Southcentral Sciences Section
Technical Report #117

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Andrew Boyd
King Wright

January 2000



*Management of ice storm
damaged woodlots and
plantations.*

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SOUTHCENTRAL SCIENCES SECTION
TECHNICAL REPORT #117
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1 Introduction

The six-day ice storm that affected some 10 million hectares (ha) of woodland in eastern Ontario, Quebec, New England and the Maritimes in January 1998 was unprecedented in its duration and severity. Severe but less destructive ice storms have hit these areas before (in 1942, 1961, 1986, and 1993) and are expected to recur every 20 to 100 years.

Damage from the 1998 ice storm was highly variable across the eastern Ontario region and even within affected stands. Severity of damage was correlated with ice deposition and was influenced by tree species, tree age, tree condition, stand structure, and exposure. For example, damage was generally less in woodlands along the shores of the St. Lawrence River where the moderating influence of a large body of water reduced ice deposition and damage.

Response of individual trees to ice storm damage was also highly variable. However, experience and research have shown that certain general principles can be applied to the physiological effects of ice storm damage on trees, so that predictions can be made about tree response. The objective of these guidelines is to provide foresters and woodlot managers with a comprehensive summary of these principles and to recommend specific management strategies and actions. A separate publication will deal with effects of the ice storm on maple syrup production and management of affected sugar bushes.

The guide is divided into eight sections that deal with specific areas of ice storm damage, woodlot management and additional resource material. The first section identifies other forest management reference materials that should be consulted for direction regarding any management activity. Section 2, **Ice Storms and Tree Damage**, presents a short historical review of ice storm dynamics, tree susceptibility, and the kinds of damage caused by these events. Section 3, **Modifications to the Management and Silviculture of Ice Storm Damaged Stands**, reminds managers that good forestry is still the best way to grow a healthy, vigorous forest. Although each forest stand is somewhat unique, this section presents some general management options and considerations for each of the four cover types addressed in this guide. This guide does not address all tree species and site types. Those included in this guide were selected on the basis of discussions and interviews with a variety of forest professionals familiar with eastern Ontario forests, commercial values, and damage caused by the ice storm. The four cover types selected (tolerant hardwoods, pine plantations, lowland hardwoods and cedar) are consistent with those used in current silvicultural guides published by the Ontario Ministry of Natural Resources (OMNR). Users of this guide should recognize that information and prescriptions presented are not applicable in every situation. They are to be used as reminders and guides for development of specific stand prescriptions. Ultimately, common sense, discretion and good forestry practices must be applied. Section 4, **Wildlife**

Habitat, discusses some positive and negative effects of the recent ice storm on wildlife in eastern Ontario and provides guidance on ways managers can maintain, create, and protect wildlife habitat. Section 5, **Hazard Trees: Safety and Access** focuses on dangers created in forests damaged by the ice storm and reminds woodlot managers of the importance of clearing potentially hazardous trees from trails and paths. Section 6, **Monitoring Forest Conditions** emphasizes the importance of having an ongoing assessment process to detect changes in the forest that may require modification of the management plan and silvicultural prescriptions. It presents a simple methodology for assessing tree condition and measuring change over time. The **Bibliography** provides a listing of additional resource materials available to readers as well as specific publications referenced in this guide. The **Appendices** contain support materials, a glossary, and a sample field sheet for monitoring activities.

1.1 The Message

The aftermath of the 1998 ice storm in Ontario was as much a human problem as it was a forest management problem. The visual impact of damage immediately after the storm was often overwhelming and landowners in affected areas were eager to respond quickly. However, with the exception of ensuring public safety and the salvage of downed red pine, there was generally little need for immediate action in terms of forest recovery or management. In fact, the best advice given in the months immediately after the storm was "Don't panic. Wait and see what happens." One year later it is still good advice in most cases. Some trees will die, but most, unless severely damaged, will recover.

There are other concerns and considerations that will influence management options and silvicultural prescriptions in affected stands. Significant changes in the relationship between crown closure and basal area now exist in some stands. Insect and disease organisms may become more prevalent and cause more damage. Managers working in lowland hardwood stands should be aware of possible impacts of their decisions and actions on water tables and the increased likelihood of flooding in some damaged stands.

Overreaction while affected stands are recovering is likely to do more harm than good. Surveys and assessments conducted in the first year after the storm indicate that management objectives and silvicultural prescriptions for affected stands and woodlots are probably as valid now as they were before the storm. There will be exceptions but, in general, woodlot managers can expect to make conservative adjustments to plans rather than major revisions.

1.2 Other Guides

OMNR has produced several guides for managing tolerant hardwoods and conifers in the Great Lakes-St. Lawrence forest region (OMNR 1986, 1989, 1998a, 1998b; Schaffer 1996). This publication is not intended to replace

those guides. They remain the authoritative documents on forest management and should continue to be used as the basis for management decisions. Other OMNR publications such as Anderson and Rice (1993) will provide additional useful information. This publication is intended to provide managers with information to support the decision-making process in stands damaged by the ice storm.

Information presented in this guide came from several sources. An extensive review was carried out of forest disturbance literature from Canada, the United States, and Europe that included key papers in forest pathology, entomology and tree physiology (Van Dyke 1999). Interviews were conducted with experts in a variety of fields; their personal experience and observations have been summarized in the text. Finally, the authors conducted field evaluations of damaged stands to gain a firsthand perspective on the varied nature of ice storm damage and to assess the recovery process.

The authors have attempted to incorporate as much pertinent information as possible to assist landowners and foresters in making accurate assessments and appropriate silvicultural prescriptions in damaged woodlots in eastern Ontario. Nevertheless, the reader should consult the references at the end of this guide for additional information.

2 Ice Storms and Tree Damage

2.1 Introduction

Ice storms, or glaze storms as they are sometimes called, occur when conditions are such that raindrops fall through layers of successively cooler air and reach the earth in a super-cooled state, occasionally at temperatures as low as $-10^{\circ}\text{Celsius}$ (C) (Lemon 1961). Ice accumulates when super-cooled rain freezes upon contact with surfaces such as tree branches that are below the freezing point (0°C). This situation typically occurs when a winter warm front passes through an area after the ground-level temperature has reached or fallen below freezing. It is most common in eastern Canada, New England and the midwestern states, where ice storms occur almost every year (Lemon 1961). The 1998 ice storm that affected eastern Ontario was the most damaging in Canadian history (Harris 1998). More than 100 millimetres (mm) of rain fell in some areas during a 6-day period in January (Atmospheric Environment Services, Environment Canada). Other recent ice storms of note include:

Ottawa, 1986: 30 mm over two days
St. John's, 1984: up to 150 mm over four days
Montreal, 1961: 30 mm over two days
Montreal, 1942: 39 mm over two days

Ice storms are not uncommon and, therefore, are an integral component of forest ecology in eastern Canada. Accumulations of ice can increase branch weight significantly (up to 30 times) (Hauer *et al.* 1994a). Small branches and weakened

limbs generally break with accumulations of 0.6-1.3 centimetres (cm). Accumulations of more than 1.3 cm can cause larger branches to break. Ice deposition during the 1998 storm exceeded this in many locations. Damage can increase significantly when strong winds accompany ice accumulation (Carvellet *et al.* 1957).

Ice damage to trees is not just a function of ice weight, but is also influenced by branch arrangement, stem taper, and the strength of the live wood (Hauer *et al.* 1994b). Severe ice storms usually result in serious breakage of major branches. Characteristics of trees that tend to increase their susceptibility to ice storms include decayed or dead branches, included bark, broad or imbalanced crowns and increased surface area of lateral branches. Included bark results from ingrown bark in branch unions. It creates a weaker union than a wood-to-wood union and is more prone to breakage under ice loading. Many hardwood trees with broad crowns (decurent) are more susceptible to ice storm damage than are conifer species with conical (excurrent) crowns. Dominant and codominant trees generally suffer more damage than intermediate or suppressed trees. Shallow-rooted trees are more susceptible to tipping due to ice accumulation than more deeply rooted species.

Tree damage is also greatly influenced by the location of the tree within the forest stand (Hauer *et al.* 1994a). Hardwoods along stand edges are often characterized by lower, longer branches and imbalanced crowns. They accumulate more ice on open sides and are more susceptible to damage. Interior trees that must compete for light tend to have smaller crowns and fewer lower branches and are generally less damaged than edge trees. Ice accumulation also tends to be greater on edge trees, especially those on windward exposures.

2.1.1 Factors Affecting Damage in Pine Plantations

Damage to trees in pine plantations includes broken leaders, laterals, and bent trees. The most severe damage to pines occurs when the main stem shatters within or below the crown. The first tree to shatter and collapse often starts a "domino effect" that results in pockets of damaged trees. Additional information on damage in pine plantations is presented in Williston (1974) and Shepard (1978).

Damage in pine plantations in 1998 generally reflected the variability of ice deposition across the region. Observations after the 1998 ice storm and after previous ice storms in the northeast indicate that several factors may affect the level and type of damage in pine plantations. These factors include:

Age

- Generally younger plantations (< 15 years) were less affected (some broken tops).
- Younger trees (5-15 cm diameter at breast height [DBH]) tended to be bent from vertical, or were uprooted.

- Most main stem breakage occurred in older plantations (> 50 years).

Edge

- Perimeter trees, which tend to be sturdier and larger in crown diameter, suffered less damage than interior trees (the reverse to what occurred in hardwood stands).

Species

- Among the conifers, pines were the most susceptible to damage.
- red pine (Pr) > white pine (Pw) > tamarack (La) > white spruce (Sw) (Appendix B).

Species Composition

- Plantations containing a mixture of tree species were generally less susceptible than single-species stands.
- In mixed plantations, irregular canopy may reduce the domino effect that can damage large pockets of trees.

Thinning/Tree Density

- Overstocked plantations that had been lightly thinned or recently thinned (< 6-7 years) sustained the most damage.
- Row-thinned plantations were generally more susceptible to damage than selectively thinned plantations.

2.1.2 Other Species

In reviewing the literature to determine relative susceptibility of various tree species to ice storm damage some general trends were observed (Downs 1938; Lemon 1961; Hauer et al. 1994b). However, the interaction of site, silvicultural history and location prevented any clear differentiation in species susceptibility. Table 1 presents a synthesis of historical reports and observations from the field, and provides a general indication of damage expected from ice storms among common tree species found in eastern Ontario. Certainly there were many exceptions. Some resistant trees were severely damaged by the 1998 storm, and some susceptible trees suffered very little damage. Nevertheless, the table is a useful general guide to potential species susceptibility.

2.1.3 General Observations from the 1998 Ice Storm (Ireland 1998)

- With the exception of red pine in plantations, trees at the forest edge suffered more damage than trees within the forest stand.
- Trees with major forks were more susceptible to ice storm damage than single-stemmed trees.

Table 1. Synthesis of historical reports and observations of the susceptibility of common trees in Ontario to crown damage caused by ice storms.

Susceptible	Intermediate	Resistant
American elm	American beech	Eastern hemlock
Basswood	Bur oak	Ironwood
Birch (white and grey)	Red oak	Spruce
Black cherry	White oak	Balsam fir
Butternut	Sugar maple	
Poplar	Ash (white and green)	
Silver maple	Eastern white cedar	
Jack pine	Tamarack	
Red maple	Red pine	
Scots pine	White pine	

- Conifers suffered less than hardwoods.
- Hemlock, balsam fir and spruce suffered the least damage. Some trees sustained broken tops.
- Individual red and white pine trees sustained light damage, but dense or recently thinned plantations often had pockets of severe damage consisting of broken or bent main stems and uprooted trees.
- Tamarack suffered broken tops, snapped main stems and broken fine branches.
- Eastern white cedar was often severely damaged, and exhibited broken or bent crowns.
- Scots pine and jack pine do not grow extensively in eastern Ontario, but where they do grow, most were severely damaged.
- Sugar maple and beech were severely damaged in some locations.
- Basswood, red maple, willow and butternut were more severely affected than sugar maple.
- Damage to oak was light.
- White birch, grey birch and yellow birch were badly bent or lost major branches.
- Main stems of aspen and poplar were broken and in many cases were stripped of major branches to produce a "poling" effect.

2.2 Tree Damage and Stress

Damaged, wounded and infected trees naturally occur in almost every woodlot or forest stand. Tree mortality is also a natural process and common occurrence. Young stands contain thousands of stems per hectare, but as they mature most of these trees die as a result of many biotic and abiotic factors. In all forest stands and woodlots affected by the 1998 ice storm, there was a sudden, and sometimes significant, increase in the rate of tree wounding and mortality.

This section will provide forest managers with an overview of potential short and long-term effects of damage caused by the ice storm on forests. These likely outcomes may influence future management objectives and decisions.

This section is not intended to be an in-depth review of tree physiology or forest pathology. Rather, a few points are presented that should be considered when assessing the health of individual trees and forest stands.

2.2.1 General Considerations

- Tree survival depends on availability of:
 - Energy
 - Space to grow
 - Water
 - Chemical elements
 - Temperature
 - Time
 - Genetic capacity to resist stress
- Tree survival is dependent on availability of tissues in the roots, trunk and foliage to store energy that will be used for growth, reproduction and defence.
- In normal, healthy trees, crowns are distributed symmetrically and wood growth is laid down in a predictable pattern along the stem (Waring 1987).
- Stem growth occurs only after the resource demands of foliage and root growth have been met; therefore, low production of stem wood may be an indication of stress.
- Trees have large storage capacities for nutrients, carbohydrates and water that can often be mobilized during periods of stress, enabling a canopy or root system to re-establish itself after it has been damaged.
- Trees are able to compartmentalize wounds, a characteristic that serves to isolate wounded or diseased tissues and thus slow or stop the spread of pathogens within the tree (Shigo 1984).
 - This process requires energy from storage tissues.
- The types of tissues affected by an injury are crucial to long-term survival.

- Injured branches and older tissue in the centre of the stem may be compartmentalized without loss of energy-storing tissues.
- Injuries to energy-storing tissues in the most recently formed growth rings create serious problems when they are walled off and energy storage space is reduced.
- When trees are subjected to environmental, mechanical or biological stress, they respond by attempting to produce flowers and seed crops.
- Trees produce seed crops annually or intermittently. This process will put additional stress on energy reserves and reduce the damaged tree's ability to regenerate lost portions of the crown.
- Trees die when they are unable to mobilize sufficient resources internally or to obtain additional resources through leaves and roots to sustain life or close wounds.
- Because energy requirements increase significantly with tree size, smaller saplings have a better chance of survival under a dense canopy than larger pole-sized trees.
- Trees under stress will show signs of crown dieback.

2.3 Marking Considerations

Before a silvicultural system and accompanying prescription can be developed and assigned to a stand, specific information concerning stand stocking, stand structure, species composition and quality variation must be analyzed and considered. The same variables are used during the tree-marking process to make "leave/cut" decisions for individual trees. An individual tree's potential growth and quality will be determined by site quality and species characteristics. Other factors such as stand history (negative disturbances) and natural variation (stand density, structure, spacing and incidence of infection courts) will all influence tree growth.

Vigour potential, or the relative capacity of a tree to increase in size, is affected by species, crown position, crown size, crown architecture, crown quality, and competition status (Anderson and Rice 1993). In many stands in eastern Ontario, the 1998 ice storm had both an immediate and long-term effect on all the above. Tree crowns were damaged or severely reduced and crown architecture was often dramatically altered. Species composition and competition relationships were also affected when trees were killed or gaps created.

The following discussion provides the forest manager with information that should be considered when evaluating tree and stand condition.

2.3.1 Crown Loss

Generally the most common damage to trees affected by the ice storm was a reduction in the crown. The severity of crown loss is a major factor in determining if and how long it will take surviving trees to recover. Table 2 provides a general overview of hardwood tree response to crown loss.

Table 2. Expected impacts on hardwood damaged by the 1998 ice storm in Ontario (adapted from Nyland 1994).

Crown Loss	¹ Probability of Survival	Growth Suppression	² Wood Degradation
<30%	Excellent	Minimal	Minimal
30% - 50%	Very good	Short-term	Variable
50% - 75%	Good	Variable, may be long-term	Variable, worse for injuries with split forks and torn bark
>75%	Poor	Severe, long-term	Severe, especially in dying trees attacked by insects

- Species vary considerably in their ability to recover from damage to branches in the crown.
 - White ash and basswood sprout prolifically to rebuild the crown.
 - Sugar maple is less resilient and often succumbs to heavy crown damage (> 50%) (Spaulding and Bratton 1946).
 - Conifers that have lost most of the live crown generally do not survive.
 - Conifers with less severe crown damage are susceptible to attack by bark beetles and wood borers that can kill trees or introduce the blue stain fungus.

Epicormic Shoots

Many tree species respond to crown damage by activating latent buds in undamaged areas of the tree to provide short-term compensation for lost photosynthetic capabilities. These are dormant buds that, as long as there are active buds above them, do not elongate any more than is necessary to keep up with diameter growth of the stem. If the upper buds are killed, then lateral buds grow out to become branches. An epicormic shoot often develops in response to a pathogen, severe defoliation by an insect, or in response to increased light levels resulting from the opening up of the stand. Epicormic shoots may also indicate internal decay or stress in certain species.

Several tree species, such as red maple, silver maple, basswood, and balsam poplar, responded to crown damage caused by the ice storm by producing large numbers of epicormic shoots in the first growing season following damage. Other species such as sugar maple were less prolific sprouters and may not be able to compensate for lost photosynthetic capability. In a study of crown removal treatments Godman and Mattson (1970) reported that epicormic branching in sugar maple increased in the second year following crown removal treatments. Although new vigorous growth was found at the beginning of the second season,

this foliage alone was not capable of supporting tree functions. This leads to the conclusion that although some trees with severe crown damage appear to compensate well in the first year or so following damage, they may die within four or five years.

There are two types of epicormic growth:

- **Watersprouts** develop on older wood located above ground.
 - These are rarely well attached to the existing wood, and almost always fail once they become large.
- **Suckers** develop from roots below ground.
 - These are not well attached and are prone to failure because of decay in the original stump and lack of connective wood between multiple stems.
- Epicormic shoots are more prolific on intermediate and suppressed trees than on dominant and codominant trees.
- Epicormic shoot development is influenced by the amount of crown damage; as damage increases, so does the amount of epicormic shoot formation.
- **When produced in the tree crown epicormic shoots can significantly contribute to tree recovery without impacting future timber quality.**
- **When produced in abundance on the main stem, epicormic shoots support tree recovery but can lead to lower timber quality.**

2.3.2 Sun-scald

In stands in which the forest canopy was significantly reduced as a result of the ice storm, the sudden and short-term (1- to 2-year) exposure of soils and tree trunks to the full heat and drying effects of the sun may result in severe physiological shock to thin-barked species and subsequent attack by sap rot fungi (Spaulding and Bratton 1946).

- Most common in young maple and beech.
- Bark in affected areas of the bole is killed and discolouration of underlying wood can occur.

2.3.3 Wounds

Few trees exist that have not been damaged at some point in their lives. By themselves, wounds may not pose a serious problem for trees. Problems arise, however, when pathogenic organisms use wound sites for entry into a host tree. Wounds can be caused by weather events (wind, snow or ice), other trees (treefall scars), animals (deer scrapings, porcupine feeding and cattle damage), and logging activity. Wounds can cause stem deformity and decay and significantly reduce final crop volume and value. Trees often have multiple wounds and

the cumulative effect of decay on lumber grade alone may be more economically significant than volume losses.

There are no absolute rules for predicting whether or not a particular wound will become infected with a decay fungus or, if it does become infected, whether or not the decay will be significant enough to degrade the value of a log. Several factors should be considered when assessing the possible impact of any wound (Shigo 1966; Nevill 1997).

Tree Species

- All wounds, regardless of cause, are susceptible to decay.
- Not all tree species are equally susceptible to decay and stain fungi (Table 3).

Table 3. Relative susceptibility of different tree species to decay and stain fungi (see Appendix B for species abbreviations).

Susceptibility	Decay		Stain	Sap rot
	Conifers	Hardwoods		
Least	Cedar	Bd	Pr	Bd
	Pines	Aw	Pj	Aw
	Spruces	Be	Pw	Be
Most	Bf	Mh	MhBy	Mh

Tree Vigour

- General tree health, as defined by site and competition, will also affect a tree's ability to defend itself from invading decay fungi.
- Young, vigorously growing trees will generally not suffer as much from infection as older, deteriorating trees because:
 - Wounds close more quickly in young trees; therefore, they are less likely to become infected.
 - Young trees grow faster than old trees, therefore, fungi grow more slowly in relation to tree growth.
- Risk of decay is influenced by relative proportions of heartwood and sapwood present at the time of injury.
 - In live trees, heartwood is more subject to decay than sapwood; therefore, wounds in younger trees that have little heartwood present less of a hazard than wounds in older trees.

- Trees already under attack from disease or insects will be less capable of resisting new fungal attacks.

Stain vectored by bark beetles will pose a threat in conifers that already contain beetle populations, but will not likely be a problem in previously uninfested areas.

Wound Depth

- Deep wounds or wounds with splintered wood are more prone to decay than shallow or smooth wounds.
- Wounds that penetrate the xylem are much more likely to lead to decay than shallow wounds that remove only the bark, exposing the cambium.

Wound Size

- Larger wounds tend to have more decay associated with them than smaller wounds.
- A general rule of thumb is that wounds $> 0.09\text{m}^2$ (1 ft²) are much more likely to become infected than smaller wounds.
- Wide wounds generally result in greater loss from decay than long, narrow wounds.
- Breaks in trunks or branches greater than 7.5 cm (3 in.) in diameter are more likely to become infected by stain causing organisms.
- Stains move vertically approximately 15 to 45 cm per year.
- Breaks smaller than 7.5 cm generally close quickly.

Wound Location

- Decay fungi more readily infect wounds near or in contact with the soil, i.e., frequency of decay generally declines as the height at which the wound is located on the tree increases.
- Wounds in the crown, especially those on small branches or wounds < 7.5 cm in diameter, seldom result in much decay or stain.
- Some broken branches in the crown will become infected with heartrot fungi, which may affect yield and degrade sawlogs. Other branches and stem wounds may become infected with sapwood rot that can cause branch and whole-tree mortality.
- Some experts claim that large branch stubs are the principal entry points for decay, while others feel that frost cracks and stem wounds are more important.

Wound Age

- Studies in hardwoods indicate that there is usually no significant spread of decay from branches into the main stem of damaged trees, for 10 to 15 years after wounding occurs. Average rate of spread is about 6-8 cm per year but this can vary depending on tree species and condition.
- Stain and decay develop in conifers much quicker (1-3 years) than in hardwoods.
- Basham (1971) found no evidence of decay or decay fungi in jack pine 7.5 and 15 years after suffering severe top breakage during an ice storm.

Wound Colour

- Dark-faced wounds (wet) are generally associated with decay, while white-faced wounds (dry) may indicate no decay. This has not been demonstrated conclusively.

Type of Fungus (Matheny and Clark 1994)

- Sap rot fungi are predominantly saprophytes that decay dead branches and exposed sapwood.
 - They have a high oxygen requirement and seldom progress far into heartwood.
 - They do not usually result in extensive defect unless there are many wounds or > 50% of the circumference of the trunk is affected.
- Heart rot fungi develop with limited oxygen.
 - They can cause extensive decay without many wounds.
 - They are usually restricted to the trunk in conifers but may extend into branches of hardwoods.

2.3.4 Bent Trees

- Trees that will recover from the bent condition have usually done so within the first growing season.
- Depending on size, surviving bent trees may break or uproot.
- Bent hardwoods are not usually subject to increased attack by insects and disease organisms.
- Conifers bent more than 60 degrees will not recover (Williston 1974).
- The recovery of saplings bent to varying degrees by the ice storm depends on species and site.
 - Birch, cherry and willow do not recover from severe bending (Lemon 1961).
 - Some species (e.g. white ash) may grow sprouts along the bent trunk reducing their potential value.

- Trees that recover may contain compression failures that seriously affect sawlog value.
 - Compression wood is formed in trees to correct a lean or bend.
 - Symptoms of compression failure may include callous swellings or, on conifers, pitch flow where the bark was broken.
 - Compression wounds have low tensile strength, higher longitudinal shrinkage rates, and a tendency to fail suddenly under tensile loads.
- Bark beetles and pathogens may invade conifers that were cracked and show evidence of resin flow.

2.4 Summary

- Trees can survive considerable crown loss (Table 2).
- Stain and decay develop slowly in healthy trees.
- Stain and decay develop quickly in logs and green lumber that are not handled properly.
- Decay does not usually spread into new sapwood formed after wounds occur, unless there is further injury.
- Some species of polewood-sized trees broken below the crown will recover by sprouting (e.g. basswood, ash, red maple).
- Tree mortality, growth loss and wood degradation are highly variable and may not become evident for several years after the injury.

3 Trees with damaged crowns and reduced foliage compensate with increased efficiency in the remaining leaves and with the production of epicormic shoots. Modifications to the Management and Silviculture of Ice Storm Damaged Stands

The following discussion addresses problems caused in eastern Ontario forests by the 1998 ice storm. Tree crowns were shattered and canopy openings were created. The response of the forest will, to a certain extent, be predictable, and is based on the growth characteristics of the tree species involved. This guide does not replace other forest management guides but is intended to address some specific problems created by the 1998 ice storm in eastern Ontario. Consult the OMNR silvicultural guides and tree-marking guides when developing and prescribing forest management activities (Anderson and Rice 1993; OMNR 1986, 1989, 1996, 1998a, 1998b). This guide provides additional information for decision-making, and should be considered a supplement to the OMNR guides.

There are additional resources available through agencies and organizations such as the OMNR, the Canadian Forest Service (CFS), the Ontario Forestry Association (OFA), the Ontario Woodlot Association (OWA), and the Landowner Resource Centre (LRC). There are also many trained and experienced forest consultants in the region that can provide professional advice and guidance.

3.1 General Considerations: All Forest Cover Types

- The choice of a silvicultural system is based on:
 - management objectives of the forest;
 - an understanding of silvical requirements of the desired species mix;
 - the current condition of the stand as a result of past management or natural influences;
 - the potential of the stand as indicated by ecosite;
- Stocking in some stands may be significantly reduced.
- **Fire hazard** may increase in stands as dead brush and trees accumulate.
- Canopy openings:
 - Small openings (diameter = 6-10 m) promote release of shade-tolerant species, such as maples, beeches and hemlocks, and effectively accelerate forest succession.
 - Large openings (diameter = 40-50 m) can increase recruitment of less shade-tolerant species and thus retard succession to some degree.
- **Frequent light crown thinning** (< 30% volume) will prevent significant openings that isolate individual tree crowns and increase susceptibility to ice damage.
- **Improvement cutting** in sapling-sized hardwood stands will eliminate stems with crooks, severely damaged stems, forks and disease, all of which would lower sawlog values.

3.2 Stocking and Canopy Closure

How has the ice storm affected normal stand development? Trees normally increase in size and decrease in number as a forest stand matures. Has ice storm damage or salvage activity significantly affected stand stocking?

Stand stocking largely influences stand growth. Silvicultural prescriptions are implemented to:

- maintain stand health;
- salvage trees that are likely to die otherwise, thereby increasing yields over the stand's rotation period;
- increase growth rates of individual trees that remain;
- achieve desired quality and species composition.

Stocking targets are designed to optimize the development of high quality products from the forest. These targets should continue to be applied in moderately damaged forests, with equal consideration given to canopy closure. Long-term sawlog potential will be seriously affected by the removal of all damaged trees if stocking and crown closure targets are

ignored. Retention of some ice-damaged trees until stand stocking and crown closure recover will help to avoid quality reduction in less damaged trees.

3.3 Salvage and Harvest Considerations

3.3.1 Markets

This guide does not include a detailed economic analysis of the impact of the 1998 ice storm in eastern Ontario, nor does it provide an in-depth discussion of salvage operations, markets, or prices for damaged wood. The worlds of macro- and microeconomics are intertwined and ever changing. Therefore, any detailed assessment at this point would likely be outdated by the time this publication becomes available.

In a preliminary assessment of effects of the 1998 ice storm on wood markets in eastern Ontario, Johnson (1998) noted that wood flow, and thus markets for salvaged wood, are complex because of:

- the large percentage of wood on private land;
- the numerous small sawmills in the region;
- outdated forest resource inventories;
- the large volumes of wood that move in from and out to other regions.

Johnson observed the following impacts of the ice storm on local markets:

- For many tree species the bulk of the most extensively damaged trees would have been considered culls, and unacceptable growing stock (UGS) prior to the storm.
- There has been little or no observed change in hardwood pulp volumes or prices.
- Much of the local hardwood pricing is driven by international market trends so prices have not changed much due to the ice storm.
- Local demand for hardwood sawlogs far exceeds the local supply.
- Reliance of regional sawmills on local conifer sawlogs resulted in both an increase in supply, and a decrease in price for those species that were extensively damaged (red pine and cedar).

Johnson concluded, "with the exception of softwood sawlogs, private lands are a minor source of wood for mills in the region. As a result, we can expect that the increase in wood supply resulting from Forest Recovery Assistance Program (FRAP) subsidized salvage operations will have a negligible impact on market demand and prices."

3.3.2 General Considerations: Salvage

Landowners should carefully assess the commercial viability of any proposed harvesting activity (Hayden, 1999 in press).

Salvage activities will be influenced by the cover type affected, management objectives, and severity of damage.

- The immediacy for salvage in pine plantations will likely be quite different than in hardwoods.
- **The extent of salvage activity will be affected by the impact it will have on basal area and crown closure, and by economics.**
- Do not formulate salvage plans on the basis of damage observed near roads, field boundaries or other edges, as such damage may not be representative of that in the remainder of the stand.
- Remove severely damaged, downed or weak conifers in the first year to prevent a build-up of bark beetles and wood borers.
- Trees with > 75% crown loss will likely die; and should be harvested within 1 to 2 years before decay and discolouration fungi affect wood quality (McEvoy and Lamson 1998).
- Downed hardwoods will degrade in one or two growing seasons.
- Any badly broken, split, bent and uprooted trees with salvage value should be harvested within the first 3 years if markets are available.
- There is no urgency (probably > 10 years) to harvest hardwoods that are lightly to moderately damaged, as the spread of discolouration and decay is much slower in these species than in conifer species.
- If damage is moderate in a recently thinned or harvested stand, salvage activity may not be commercially viable.
 - It will be better for long-term woodlot potential if damaged stems are retained until the next harvest rather than over-harvest below stocking targets. Epicormic branching may form in these stands and may lower the value of residual trees.
 - Conduct a small-scale salvage as required.
- Consider leaving some (e.g. six cavity trees per hectare) of the larger damaged hardwoods and conifers to provide valuable wildlife habitat (Section 4).
- **In stands inflicted with *Armillaria* root disease, delay salvage until desirable crop trees have recovered from storm damage.**

Prevent Residual Stand Damage

- Avoid damage to residual trees during harvest operations.
- A wound on the butt log represents a far more serious economic loss than a wound from a broken limb in the crown.
- Avoid harvesting during spring when soft ground can cause excessive root injury.
- Avoid harvesting during the growing season, from April to July, when residual trees are much more susceptible to wounds caused by felling and skidding.

Post-harvest Maintenance

- Cut severely damaged trees left by loggers.
- Monitor the stand carefully for 3 to 5 years to assess recovery and deterioration.
- Tree condition and general stand health may be easier to assess when the tree is in leaf, as leaf size, colour, density, and distribution are good indicators of tree health.

Finally, don't rush to liquidate a damaged woodlot.

More detailed information on cutting and selling timber is available from the OMNR, LRC, OFA and OWA.

3.4 Pine Plantations

Based on the number of plantations present in eastern Ontario and damage caused by the 1998 ice storm, this discussion focuses on red pine plantations. White pine plantations are generally young in eastern Ontario, suffering mostly broken or bent tops. Many options presented for red pine are equally applicable to young plantations of other pine species, including jack pine and Scots pine, growing on sites suitable for timber production.

Quality and quantity of saleable wood products from red pine plantations depend on previous efforts to control stand density. Key factors include initial spacing, timing of thinning operations and amount of thinning. Thinning is a significant mechanism for controlling stand growth and shaping future stand structure. It helps to increase the diameter growth of crop trees in the residual stand, maintain stand health, salvage trees that are likely to die, achieve desired quality and species composition, and improve stand quality. When red pine is left unthinned, its diameter growth is greatly reduced, and it will develop tall, spindly stems that are susceptible to storm damage. Density management is essential for optimal stand growth (Richardson *et al.* 1994). For detailed discussions of this management activity, consult the various guides published by OMNR (OMNR 1986, 1989, 1998b).

3.4.1 Management Options and Considerations for Red Pine Plantations

Red pine plantations typically suffered light-to-moderate damage, with some patches of severe damage that varied considerably in size. Therefore, the discussion of management options is directed at severely damaged trees within the affected plantations. Key factors to assess before taking any action include:

- distribution of severely damaged trees within the plantation (patchy or even)
- size of patches;
- presence or absence of regeneration of desirable species;
- age of trees.

Immature Plantations (< 15 cm DBH)

- Although costs may be prohibitive, corrective pruning of damaged leaders may be an option to maintain future timber value of high value trees (< 3m).
- The timber-quality potential of the plantation can be maintained:
 - If there are at least 1000 well distributed, undamaged or lightly damaged trees/ha in plantations >1.5m tall and <15 years old.
 - If there are at least 800 evenly spaced undamaged or lightly damaged trees/ha (40% dominant and codominant) in plantations >15 years old.
 - If there are at least 500 well distributed lightly damaged or undamaged trees/ha (40% dominant and codominant) in plantations that have already been thinned.
- The presence of canopy gaps provides an opportunity to expand the species diversity in plantations by planting mid-tolerant hardwoods such as oak and ash.
 - Consider shade tolerance of species if patches are small.
 - Intolerant species in small canopy gaps may not receive enough sunlight to survive.
- In severely damaged plantations, liquidation, followed by site preparation and planting of a suitable species is an option.

Mature Plantations (> 15 cm DBH)

- If severely damaged trees are evenly distributed, selectively remove stems that have sustained the most damage.
 - If volume is not sufficient, fell damaged trees and dispose of slash to reduce risk of pest attack.
- If damage is in small patches, liquidate damaged patches to encourage regeneration, or underplant with suitable species.

- If damage is in large patches, remove severely damaged trees and leave some of the moderately damaged trees for protection and a seed source.
- If there is no suitable regeneration present, and no nearby seed source, clean up the area, site prepare and replant.
- Trees with timber value that lost more than 75% of the crown, or were up-rooted, or bent (> 60 degrees) should have been harvested before June of the first year to reduce risk of infection by blue stain fungi.
- Remaining trees and bent trees that do not recover should be slashed to the ground to encourage decomposition.
- Bent trees that have straightened may have compression damage that will increase their susceptibility to breakage, and reduce sawlog quality.
 - Compression failures are most common in young trees with tall slightly tapered stems.
 - Trees that show evidence of compression failure should be removed in the next scheduled thinning.

3.4.2 Potential Pest Problems

Attack of residual trees by bark beetles is possible in all stands damaged by the ice storm. Insects, such as the pine engraver (*Ips pini*), attack weakened host trees or recently dead host material. Plantations that had bark beetle problems before the ice storm are especially susceptible to a build-up of bark beetle populations on residual trees (Section 6.4).

- Outbreaks may be prevented by appropriate slash disposal, and removal of infested trees. Scattering slash in the open to allow the sun to dry it out will make it an unsuitable host. Keep large accumulations of slash away from the bases of residual trees.
- Red pine is susceptible to infection by fomes root rot. Avoid unnecessary damage to residual trees and treat freshly cut stumps with a fungicide.
- To minimize potential impacts of *Armillaria*, give trees in affected stands time to recover before any unnecessary cutting.

3.4.3 Fire Hazard

Two general forms of fuel alteration were reported by OMNR:

1. Scattered tops and branches throughout the stand.
 - These had no significant effect on fire behaviour because of the scattered nature of the fuels.
2. Areas of severe damage with complete crowns on the ground or hung up in the remaining stand.

- These created pockets of very flammable material that could increase flame length and intensity.

Recommendations:

- Clean up accumulations of slash within 150 m of buildings and 30 m of public roads.
- Cut and burn or cut and chip woody debris to reduce the risk of insect and disease problems.

3.4.4 Managing to Reduce Plantation Vulnerability

- Start thinning at an early age (at 15 cm DBH), keep them light and frequent to maintain sturdy boles and compact, symmetrical crowns.
- Avoid growing tall, weak, small-diameter trees. Clearcut and replant areas too old to respond favourably to thinning.
- Recently thinned stands remain susceptible to ice storm damage for several years after thinning as trees are robbed of mutual support.
- When thinning, try to retain trees with symmetrical, balanced crowns.
- Thin from below to release dominant trees.
- Mixed-species plantations may be less susceptible to ice storm damage.
- Selectively thinned plantations may be less susceptible to ice damage than rowed thinned plantations.

3.5 Tolerant Hardwoods

The tolerant hardwood cover type of southern Ontario is usually dominated by one or more of the following species: sugar maple, beech, hemlock, red oak, white ash, red maple and black cherry. Common associates include ironwood, basswood, bitternut hickory, white pine, white birch, yellow birch and butternut (Elliott 1998). Species specific characteristics for selected tolerant hardwoods in eastern Ontario are summarized in Table 4.

Growth and development in managed tolerant hardwoods are optimized by regulating stocking density:

- In uneven-aged stands, by comparing post-ice storm stocking density and stand structure (i.e. distribution of stocking by size class) to recommended residual stocking levels for southern Ontario (Table 5).
- In even-aged stands, by comparing post-ice storm stocking density with the stocking guides for the appropriate species provided in OMNR (1998a).

Table 4. Tolerant hardwood species characteristics.

Species	Common Defects	Silvics
Sugar Maple	- Relatively resistant to decay because of the slow formation of heartwood. - Wounds in the crown, except for those on large branches in which rot will move downward from the stubs in approximately 10 years, often close without infection. - Prone to weak unions, cracks and cankers (<i>Eutypella</i> and <i>Nectria</i>). - Canker rot caused by <i>Monilia</i> and sap rot caused by <i>Cerena</i>. - Young stems may be attacked and trees killed by the sugar maple borer, <i>Glycobius speciosus</i>.	- Very shade-tolerant - Does not respond to crown loss with vigorous sprouting; hence, trees with > 50-60% crown loss are not likely to resume vigorous growth or add sufficient increment fast enough to warrant retention unless they are near sawlog size. - Responds very well to release created by canopy thinning - Excessive release may result in persistent stem forks and increased susceptibility to sunscald, top decline and attack by sap-rot fungi. - Seed crops: - Produces seed at age 30 - Produces some seed annually but heavy crops every 3-7 years
Black Cherry	- Very resistant to decay in crown injuries. - Large trunk wounds present major decay hazards. - Prone to branch breakage close to stem.	- Intolerant of shade - Sprouts readily from stumps of all sizes, although sprouts from merchantable-sized stumps generally develop poor form and rot. - Generally responds poorly to release, but vigorous trees may show some response to thinning - Sudden exposure may produce sunscald, stag-head and general decadence - Tends to produce epicormic branches - Seed crops: - Produces seed at 10 years - Produces some seed annually but heavy crops every 1-5 years
American Beech	- Susceptible to decay. - Severe injuries to trunk or crown in older trees will limit their chances of reaching merchantability.	- Very shade-tolerant - Does not respond to crown loss with vigorous sprouting (similar to sugar maple) - Sprouts well from stumps up to 10 cm in diameter

Species	Common Defects	Silvics
American Beech (continued)		- Root suckers may develop around older trees, but few develop into good trees because they lack an independent root system - Proned to sunscald and epicormic branching after sudden exposure as a result of heavy thinning (> 50% basal area removed), especially if the trees are <10 cm DBH. - Seed crops: - Produces seed at age 40+ years - Produces heavy seed crops every 2-8 years
Basswood	Rots and decays in the main stem are generally negligible; trees can be left for up to 10 years before harvest.	- Shade tolerance is intermediate in seedlings but increases significantly in older trees. - Responds to crown damage with profuse sprouting and can be held over up to 10 years to gain increment. - Basswood is a prolific stump sprouter up to 100 years of age but early thinning of sprout clumps (leaving no more than two residual sprouts) is essential at about 10 years or 5 cm DBH. - Seed crops: - Produces seed at age 10+ years. - Produces annual seed crops
Yellow Birch	- Trunk wounds of any kind present major decay hazards; decay progresses quickly. - Opening of crowns leads to gradual decline and, finally, death of tree. - Dead trees decay rapidly. - Proned to lower stem breakage, dieback or decline, and attack by <i>Agrius</i> borers	- Intermediate in shade tolerance - Often regenerates successfully and competes in small openings of 0.1 ha or less - Can form sprouts from seedlings or small stumps but these are usually low in vigour - Because of relatively slow growth and poor response to release, may be partly suppressed by more rapidly growing adjacent trees - Epicormic branching is a common response to crown damage - Seed crops: - Produces seed at age 40+ years - Produces heavy crop every 3 years.

Species	Common Defects	Silvics
White Ash	Less prone to rot than basswood and can generally be left more than 10 years	- Intermediate in shade tolerance - Responds to crown damage with profuse sprouting - Sprouts readily and grows rapidly from cut seedlings and saplings - Can be held over longer than basswood because it has greater re-sistance to rot. - Dominant and codominant trees respond well to thinning or release - Seed crops: - Produces seed at age 20+ years - Produces crop every 3-5 years
Red Oak	- Susceptible to <i>Stromella</i> canker and <i>Phellinus</i> canker-rot - Vulnerable to <i>Armillaria</i> root disease and attack by <i>Agrilus</i> borers. - Surviving trees may be more vulnerable to attack by defoliators such as the forest tent caterpillar, oak leaf shredder and gypsy moth.	- Intermediate in shade tolerance - Reproduces easily by stump sprouting, especially from small stumps. - Responds well to release, especially saplings and pole-sized dominants or codominants. - Produces epicormic branching after heavy release or in response to crown damage. - Stump sprouts can produce good quality trees if they originate at or below ground level (less likely to decay). - Seed crops: - Produces seed at age 20+ years. - Produces crop every 2-5 years.

3.5.1 Management Options and Considerations for Tolerant Hardwoods

It would be impossible to address every potential field situation in areas damaged by the ice storm. Instead, forest situations in the tolerant hardwood cover type have been separated on the basis of management strategy. Because management options for moderately and severely damaged stands differ only in degree; they have been grouped to eliminate repetition.

Damage Definitions

1. Moderate: Most trees (> 50%) have between 25% to 75% crown damage.
2. Severe: Most trees (> 50%) have more than 75% crown damage.

Procedures for determining the severity of ice storm damage in woodlots are provided in Appendix C.

Crown closure was significantly reduced in some stands damaged by the ice storm. Residual tree spacing and crown density are important factors to consider with semi-tolerant species such as black cherry, yellow birch and red oak. These species require use of specific reproduction methods to ensure successful renewal. Residual crown closure ranging from 40% to 80% is usually prescribed, depending on species.

Management prescriptions must take into consideration the objectives of the landowner and the following stand characteristics:

- the degree of damage caused by the ice storm,
- the amount, distribution and species composition of regeneration,
- the amount, distribution and desirability of understory vegetation (e.g., buckthorn, prickly ash, raspberry),
- the wildlife values to be retained,
- species diversity,
- in young stands:
 - the distribution of undamaged trees,
 - the sprouting potential of the species present,
 - the presence or absence of overstory trees.

Uneven-aged Management

Consider conversion to an even-aged stand using the uniform shelterwood system if the acceptable growing stock (AGS) of the remaining stand falls below 9 m³/ha (in trees > 9 cm DBH) (OMNR 1998a). The objective would be to regenerate a new stand, not to manage the present overstory.

When making management decisions regarding uneven-aged stands, be conservative with recommended residual basal areas (Table 5), especially in stands that suffered heavy damage. Residual basal area prescriptions were developed on the basis of information gathered from normal, relatively healthy stands. These prescriptions do not take into account the increased levels of tree mortality that are likely to occur in some stands damaged by the ice storm.

Table 5. Recommended residual stocking levels by size class for uneven-aged management in central Ontario (OMNR 1998 a).

Size Classes	Equivalent Diameter Class (cm DBH)	Basal Area (m ² /ha)	No. of Trees/ha
Polewood	10 to 24	6	333
Small Sawlogs	26 to 40	6	100
Medium Sawlogs	42 to 48	3	21
Large Sawlogs	50+	3	12
Total		20	466

Uneven-aged management - Moderate and Severe Damage

- Assess the quantity and quality of remaining stems.
- Assess the pattern and distribution of damage.
- If damage is evenly distributed, use a single crop-tree management system, i.e., select the best of the residual trees and manage for them.
- If the damage is patchy use a group-selection management system to facilitate the regeneration of species of intermediate shade tolerance such as yellow birch, red oak, white ash and occasionally black cherry.
- If AGS falls below 9 m³/ha, (trees > 9 cm DBH) consider converting stand to even-aged structure using the uniform shelterwood system.

- Use residual basal area and regeneration potential to determine the total amount of wood removed.
- Target basal area = 20 m²/ha, (trees > 10 cm DBH) but consider crown closure and possible effects on the development of existing trees (Table 5).
- Select to leave the best, individual, well-spaced crop trees.
- Do not remove more than 1/3 of the basal area even if undesirable trees (UGS) have to be retained.
- Consider species diversity and try to avoid elimination of any one species.
- To encourage replacement of desirable species in severely damaged sapling and polewood size classes cut stems close to the ground in the dormant season to encourage coppicing (see Table 4 for individual species sprouting potentials).

Even-aged Management

Moderate and Severe Damage

- Assess the condition and distribution of the remaining stems.
- Use the uniform shelterwood system if the damage is evenly distributed throughout the stand and group shelterwood where damage is concentrated in pockets.
- If damage is severe, evenly distributed, and very few trees remain, consider clearcutting (a new stand should develop from existing seedling regeneration, soil seed bank and sprouts).
- **Consult individual stocking guides (OMNR 1998a, 1998b) for species specific residual stocking recommendations.** Maintain optimum stocking levels above the B-Line (appendix A) but consider crown closure and possible effects on the development of existing trees.
- Use residual basal area and regeneration potential to determine the total amount of wood removed.
- A minimum residual basal area of 15 m²/ha is recommended to minimize the development and persistence of epicormic shoots, and to maintain optimum volume growth.
- Consider species diversity and try to avoid over-removal of any one species.
 - Polewood stands with moderate damage that still have quality potential should be treated by even-aged thinning. In polewood stands, maintain a minimum stocking level of 14 m²/ha (> 10 cm DBH) even if undesirable trees have to be retained.

- If quality potential is unacceptable, maintain a minimum stocking level of 11 m² ha (> 10 cm DBH) to provide shelter and seed in shelterwood stands, even if undesirable trees (UGS) have to be retained.
- If there is no overstory potential, concentrate on developing the understory (e.g., uniform or group shelterwood).
- Encourage seeding in canopy gaps of desired species as per OMNR (1998a).
- To encourage replacement of desirable species in severely damaged sapling and polewood size classes cut stems close to the ground in the dormant season to encourage coppicing (see Table 4 for individual species sprouting potentials).
- Use clump thinnings to manage resulting coppice growth.

In all of the above situations, consider stand liquidation only when there is absolutely no quality potential and no regeneration of desirable species in the understory.

3.5.2 Potential Pest Problems

Significant increases in pest activity are not expected to occur in tolerant hardwood stands. However, landowners should monitor conditions in affected stands carefully to ensure early detection of potential pest problems (Section 6.5).

- **To minimize potential impacts of *Armillaria*, give trees in affected stands time to recover before any unnecessary cutting.**

3.5.3 Fire Hazard

- In the first year, most of the additional fuel loads on the ground in hardwood stands consist of green wood that will likely take at least one year to cure.
- This may affect the behavior of spring and fall leaf fires in 1999.
- Increased canopy openings will result in an abundant shrub or regeneration layer that will reduce the hazard in these stands once green-up has occurred.

Recommendations

- Cut broken branches to the ground to encourage decomposition and reduce the fire hazard.
- Clean up accumulations of woody debris within 150 m of buildings and 30 m of public roads.
- **Do not burn brush piles until after green-up. This will reduce the risk of the fire escaping into grass or leaf fuels and will allow time for brush piles to dry, cure and burn completely.**

3.6 Lowland Hardwoods

Dominant tree species in the lowland, or intolerant, hardwood forest are silver maple, red maple, green ash, black ash, white elm, hemlock, and yellow birch (Elliott 1998). Common associates include trembling aspen, balsam poplar, basswood, white birch, white cedar, balsam fir, red elm, black maple, butternut, white pine, white ash, sugar maple, largetooth aspen and bur oak. Species specific characteristics of lowland hardwoods are presented in Table 6.

- Intolerant species will form poor stems if stand density (basal area) is not maintained.
- Heavy cuts on low sites can result in elevation of the water table and drowning of stumps.
 - In stands heavily damaged by the ice storm, any further thinning should probably be delayed until crown replacement is sufficient to minimize possible effects on the water table.
- It is essential to maintain high stocking levels if tree form is important. As the ice storm reduced stocking in some stands, the only option may be to focus on regeneration in these stands.

Table 6. Lowland hardwood species characteristics.

Species	Common Defects	Silvics
Red Maple	- Trunk wounds of almost any kind present major decay hazards. - Little resistance to decay; infections tend to progress quickly. - Prone to weak unions, cracks and cankers (<i>Eutypella</i> and <i>Nectria</i>).	- Intermediate in shade tolerance - Sprouts vigorously (improve clumps by thinning at an early age: no more than two residual sprouts at about 10 years or 5 cm DBH). - Sprouts originating below the root collar are more likely to produce higher quality timber. - Responds well to release after relatively short periods of suppression. - Quickly replaces damaged crowns. - High potential growth rate. - Seed crops: - Production begins at age 4. - Produces seed crops almost every year with a bumper crop every 2 years
Silver Maple	- Trunk wounds of almost any kind present major decay hazards - Trees > 35 cm DBH are prone to branch breakage during storms. - Weak unions, cracks and cankers (<i>Eutypella</i> and <i>Nectria</i>) are common.	- Intermediate in shade tolerance but not as tolerant as red maple. - Prolific stump sprouter up to 100 years of age, but early sprout clump thinning is essential (no more than two residual sprouts at about 10 years or 5 cm DBH). - Quickly replaces damaged crowns. - Very high potential growth rate. - Seed crops: - Production begins at 11+ years. - Produces annual seed crops.
White Birch	- Trunk wounds of any kind present major decay hazards; decay progresses quickly. - Opening of crowns leads to gradual decline and, finally, death of tree.	- Intolerant of shade. - Requires an opening > 0.1 ha to regenerate. - Sprouts from stumps less than 60 years old, but these are usually low in vigour.

Species	Common Defects	Silvics
White Birch (continued)	- Dead trees decay rapidly - Prone to lower stem breakage, dieback or decline, and attack by <i>Agilus</i> borers. - Very susceptible to discoloration and decay by microorganisms that enter the bole through wounds or branch stubs (<i>Inonotus</i> and <i>Phellinus</i>).	- Responds to release when young. - Relatively slow growing. - Saplings and pole-sized trees bent by snow or ice. - Generally recover and straighten if the burden falls off quickly. - Trees that are still bent after one growing season will not straighten. - Seed crops: - Production begins at age 15. - Produces seed crops every 2 years.
Black Ash	- Susceptible to branch breakage, especially in trees > 35 cm DBH. - Multiple codominant stems often result in poor architecture. - Somewhat resistant to decay.	- Intolerant of shade. - Responds poorly to release, except for dominant and codominant trees. - Sprouts moderately (forms coppices) and grows rapidly from cut seedlings and saplings. - Produces heavy seed crops every 1-8 years.
Balsam Poplar	- Damaged trees are prone to canker (<i>Cytospora</i> canker) and decay through wounds. - Has little resistance; infections tend to progress quickly. - Major trunk wounds of almost any kind present a major de-cay hazard. - Dead trees decay rapidly.	- Intolerant of shade. - Root and stump sprouts may develop around older trees but few develop into good trees because they lack an independent root system. - If balsam poplar is present, it is generally one of the first species to recolonize open, damaged areas. - Seed crops: - Production begins at age 8-10. - Large crops produced almost every year.
Trembling Aspen	- Susceptible to <i>Hypoxylon</i> canker. - Decay caused by <i>Phellinus</i> is common in older aspen.	- Intolerant of shade. - Reproduces most commonly from adventitious root sprouts (suckers), but few develop into good trees because they lack an

Species	Common Defects	Silvics
Trembling Aspen (continued)	· Has little resistance to decay; infections tend to progress quickly. · Dead trees decay rapidly.	independent root system. · Suckering is suppressed by auxins transported from growing shoots; consequently, parent stands must be removed (e.g., by fire or clearcutting) so that suckering can occur. · Exposing the forest floor to sunlight and warmth enhances suckering. · Trembling aspen is generally one of the first species to recolonize open, damaged areas. · Seed crops: · Produces seed crops after age 10-20. · Good crops every 4-5 years.

3.6.1 Management Options and Considerations for Lowland Hardwoods

Attempts at the intensive management of lowland hardwoods have often been unsuccessful. **Problems associated with rising water levels, dieback and decline, low product costs and increasing harvesting costs have made management difficult.** Therefore, any post ice storm activity in these stands should be carefully evaluated.

Even-aged Management

Moderate and Severe Damage

- In stands with an understory of intermediate tolerants, gradually remove the overstory to release the regeneration.
- Recommend a shelterwood cut of the most heavily damaged trees on the basis of their distribution:
 - If damaged trees are evenly distributed, use a uniform shelterwood system.
 - If damage is patchy, use a group shelterwood system or patch clearcut.
- Base the total amount removed on the residual basal area (no less than 14 to 16m²/ha), the possible effects on crown closure, and the development of remaining trees.
- Attempt to maintain species diversity.
- Use clump thinning to manage the resulting root/stump sprouts.
- Trees should be cut during the dormant season and as low to the ground as possible to stimulate coppice growth.
- Consider tree age, coppicing is poorer in older trees (> 20 cm).
- When using the shelterwood system, time the removal cut on the basis of the stocking of the regeneration and/or the demise of the overstory.
- If managing for poplar, retain the best stems to ensure regeneration of the best clones.
- Polewood stands that have quality potential should be treated by even-aged thinning.
- Allow tolerants to invade from adjacent stands.

3.6.2 Potential Pest Problems

Significant increases in pest activity are not expected to occur in lowland hardwood stands. However, landowners should monitor conditions in affected stands carefully to ensure early detection of potential pest problems (Section 6.5).

- To minimize potential impacts of *Armillaria*, give trees in affected stands time to recover before any unnecessary cutting.

3.6.3 Fire Hazard

- In the first year, most of the additional fuel loads on the ground in hardwood stands consist of green wood that will likely take at least one year to cure.
- This may affect the behavior of spring and fall leaf fires in 1999.
- Increased canopy openings will result in an abundant shrub or regeneration layer that will reduce the hazard in these stands once green-up has occurred.

Recommendations

- Cut broken branches to the ground to absorb moisture and reduce the fire hazard.
- Clean up accumulations of woody debris within 150 m of buildings and 30 m of public roads.

Do not burn brush piles until after green-up. This will reduce the risk of the fire escaping into grass or leaf fuels and will allow time for brush piles to dry, cure and burn completely.

3.7 Cedar

Eastern white cedar is the dominant coniferous species in eastern Ontario (Elliott 1998). Common associates are balsam fir, white birch, hemlock, tamarack, white spruce, trembling aspen, and largetooth aspen.

Cedar stands in eastern Canada are often managed for both timber and wildlife values. These areas are particularly valuable as deeryards during severe winters as they provide both shelter and browse. Wherever possible, manage cedar in relatively large, even-aged stands, as these appear to be best for timber production and deeryard maintenance. Consult Schaffer (1996) for a more thorough discussion of cedar management. Species characteristics are presented in Table 7.

Table 7. Characteristics of eastern white cedar.

Species	Common Defects	Silvics
Eastern white Cedar	· Uprooting and breakage occur along stand edges and in stand openings. · Few serious insect or disease problems - mainly carpenter ants and leafminers. · Often affected by a compartmentalized butt rot. · Very resistant to decay. · Generally can be left for many years.	· Shade tolerance: · Seedlings that develop from seed are shade intolerant. · Shade tolerant when it reproduces vegetatively through the layering of shoots from its branches and stems but develops best in partial to full sun-light. · Layering, principally that of branches, and the formation of vertical stems from windthrown trees are a common means of reproduction in moist areas. · Layering is most common in younger stands (>> 5 years) and where windthrown trees are prevalent. · Management in these areas is difficult. · Cedar has excellent crown regeneration potential; therefore, lightly to moderately damaged crowns will likely regrow. · Responds well to release at nearly all ages and response improves with site quality. · Responds poorly to thinning in poorly drained swamps. · Heavy slash can hinder cedar establishment and may provide habitat for hares that browse on cedar. · Light slash can aid establishment. · Seed crops: · Produces seed at age 20+. · Produces good seed crops every 3-5 years.

3.7.1 Management Options for Damaged Cedar

- Where damage is patchy, consider salvaging individual trees, narrow strips, or small patches of damaged stems to maximize timber production and maintain deeryards.
- In mature stands:
 - Remove the affected overstory in two or more cuts leaving uniformly spaced dominant and codominant trees selected for wind firmness, seed production and timber quality (residual basal area of 14m²/ha).
- In immature stands:
 - If competition from other species is not a concern, remove damaged trees to a basal area of 30m²/ha and re-thin every 10 years.
 - If competition from other species is a concern, it is generally best not to thin below 34m²/ha.
- The United States Department of Agriculture (USDA) recommends a residual basal area of 34 m²/ha to maintain deer shelter and inhibit undesirable growth (Johnston and Booker 1994).
- Skid tree length to minimize slash in cut areas.
- Consider planting large damaged patches, as seeding success in such areas can be very poor.
- On wet sites, clean up where necessary, and regeneration by layering will probably continue.
- Slash dead material to the ground to encourage decomposition and remove it from trails if the stand is used as a deeryard.

3.7.2 Potential Pest Problems

Cedar has few serious pest problems that are likely to be exacerbated by the ice storm. Heavy browsing by deer may become a problem on young trees (< 10 years) and in some areas hare browsing may also be significant.

3.7.3 Fire Hazard

- Cedar in dense stands on wet sites is not a significant fire hazard except under extended drought conditions.
- A significant amount of fuel in the form of broken tops may increase fire intensity on dry sites.

Recommendations

- Remove plant debris or slash it to the ground to encourage decomposition and reduce fire hazard.

4 Wildlife Habitat

The ice storm of 1998 drastically altered the forest ecosystem in many areas. In some cases the storm had a negative impact on wildlife habitat, while in others it may have improved habitat for certain wildlife species. For example, as they regenerate, severely damaged stands will provide wildlife with an abundance of food and cover close to the ground.

Forest management on private land in southern Ontario has changed dramatically during the past decade. Many landowners are no longer making decisions solely based on timber management objectives. Instead, they are thinking about maintaining wildlife habitat, promoting biodiversity and protecting environmental quality. The ice storm has refocused attention on forest management activities. Part of the assessment and decision-making process should include the recognition of key habitat features for retention.

The forests of eastern Ontario are home to almost 200 species of birds, mammals, reptiles and amphibians. Good forest management practices, such as the use of the single-tree selection system in hardwood stands, generally produce good wildlife habitat if landowners make a conscious effort to protect and maintain the following six key components of wildlife habitat. Retention of these habitat components involves only minor fine-tuning of current silvicultural practices, and will allow landowners to produce high-quality wildlife habitat and timber products as the forests recover from the effects of the ice storm.

Stick Nests: platforms made of sticks or twigs that are used for nesting by large birds (e.g. species such as eagles, ospreys, red-shouldered hawks and goshawks)

- These are used repeatedly; once abandoned, they are used by other bird species such as great-horned owls.
- The nests of rare species such as eagles, ospreys, herons, red-shouldered hawks, Cooper's hawks and northern goshawks are of special concern and should receive special protection.
 - **To maintain preferred habitat for these species in stands where canopy closure has been reduced below 70%, consider delaying harvest activity until the crowns recover.**
- Save nests of other more common species such as the broad-winged hawk, red-tailed hawk, sharp-shinned hawk and merlin.
- Attempt to retain trees immediately adjacent to nest trees.
- There is no need to retain bear nests, which are usually found in beech, oak, poplar, and black cherry.

Cavity Trees: trees with cavities or holes used by birds and mammals for nesting, denning, roosting, resting, feeding or hibernating

- These are generally standing dead trees (snags) or living trees that are in decline.
- There is concern that the “clean-up” of stands damaged by the ice storm will remove many of the available cavity trees.
- Current OMNR guidelines for Crown lands specify the retention of at least six living cavity trees per hectare in all harvest blocks.
 - Cavity trees should be at least 25 cm DBH (with at least one tree > 40 cm DBH).
 - Recommended priority is based on type of cavity:
 - Pileated woodpecker roost or nest cavity
 - Other woodpecker nest cavities
 - Escape cavities
 - Woodpecker feeding excavations
 - Potential cavity trees

Downed Woody Debris (DWD): logs, branches or stumps on the forest floor used by wildlife

- Provides feeding sites, plucking sites, cover from predators, display sites, travel routes, moist microsites, nesting sites, winter resting sites, maternal sites and hibernating sites for a variety of animals.
- The ice storm has created an abundance of this material.
- Consider the following OMNR guidelines for Crown lands when salvaging or cleaning up damaged stands:
 - Whenever possible, leave unmerchantable portions of tree boles at harvest sites to provide large-diameter DWD. (Bigger is better.)
 - Where you will not be compromising silvicultural objectives and health and safety concerns, consider girdling or felling and leaving unmerchantable stems.
 - If you are using site-preparation equipment, try to minimize windrowing or crushing of DWD.
 - Leave in place and undisturbed both the older, decayed DWD and the sound DWD resulting from the aftermath of the ice storm.

Mast Trees: “Mast” refers to the edible fruits of both overstory and understory plants

- Soft mast, such as blueberries and cherries, and hard mast, such as acorns and beechnuts, is eaten by over 75 species of birds and mammals in the forests of eastern Ontario.

- Oaks, beech, basswood, black cherry, butternut, hickory, walnut and ironwood are all important mast-producing trees for wildlife use.
- A minimum of seven or eight mast trees per ha, no more than 50 m apart, will help ensure successful pollination and seed-set of mast crops.
- Mast trees should be at least 25 cm DBH. Most species reach a peak in seed production during middle age. Among oaks, trees between 40 and 65 cm DBH produce heavy acorn crops.
- Try to retain trees of seed-bearing age with large, rounded, vigorous crowns.
- Look for trees with evidence of previous use by wildlife, such as beech trees with bear claw marks or bear nests.
- The crowns of some trees were so severely damaged by the ice storm that they might not be good choices to retain for mast production.
- Consider managing the stand to ensure mast production into the distant future by creating conditions favorable to the regeneration of the desired species.

Conifer Cover

- Conifer cover is an extremely important component of wildlife habitat in eastern Ontario, especially for white-tailed deer.
- It provides important thermal cover for deer in winter.
- Conifers intercept snow in their foliage and hold it above the ground, reducing the snow depth below their foliage.
- Snow depth determines the area of a deeryard accessible to deer and thus the amount of food available.
- To manage conifer stands for deer:
 - Maintain at least 60% canopy closure within pockets of conifer.
 - Maintain at least 80% canopy closure on knobs that provide good potential bedding sites.
 - Clumps of three or more conifers, at least 10 m tall, and with interlocking crowns, can also provide important deer cover in hardwood stands.
 - Retain scattered conifers that appear to link shelter patches together if they are no more than 30-50 m apart.
 - Scattered conifers in hardwood stands, whether in pockets or in clumps or as solitary stems, provide habitat for other wildlife besides deer.

For scattered conifers the following procedures are recommended:

- When there are 10 or fewer conifers per ha (basal area ≤ 2 m²/ha), retain at least five conifers per ha and remove only those that compete with very high-quality hardwoods.
- When there are more than 10 conifers per ha (basal area > 2 m²/ha), retain at least 10 conifers per ha and treat remaining conifers to meet silvicultural objectives.
- Retain trees that are at least 25 cm DBH and preferably more than 40 cm DBH.
- Retain long-lived conifers (e.g., hemlock, red spruce, white pine and white spruce)
- Retain low-risk trees of high vigour, as well as those needed to meet cavity-tree objectives.
- Retain trees in clumps (three or more), as these are especially valuable.

Supercanopy Trees: living trees that protrude above the main canopy of a stand.

- Their open crowns make them ideal nest and perch sites for large raptors such as bald eagles, ospreys, turkey vultures and red-tailed hawks.
- Retain some supercanopy trees in a forest or woodlot, as long as they are not severely damaged.
- Studies in Minnesota suggest that retention of at least one supercanopy pine or hemlock tree > 50 cm DBH for every 4 ha of forest will enhance the suitability of the forest as bear habitat.
- OMNR's eagle guidelines recommend retention of at least one supercanopy tree per 16 ha around eagle nests, and at least one supercanopy tree per 650 m of shoreline.

5 Hazard Trees: Safety and Access

Before taking any action in a woodlot damaged by the 1998 ice storm, make safety your first consideration. **Safe access** to damaged woodlots and plantations is essential if you are going to engage in monitoring and management activities. **You must ensure that roads, paths and trails leading to these areas are safe.** The methodology and recommendations for remediation presented here are not intended to be applied at the stand or woodlot level, but to those **hazard trees** that are proximate to areas, such as access routes, where human safety is a special concern.

5.1 Recognizing Hazard Trees

A hazard tree is a tree with structural defects likely to cause failure of all or part of the tree, which could then strike a target. A target can be a vehicle, a building, or any place that people frequent.

Evaluating trees that present a safety hazard is a complex process influenced by the tree species, location, severity of damage, and site conditions. The following are guidelines, not absolute rules, for recognizing and correcting hazardous defects. **When in doubt, consult a professional.**

5.2 General Safety Considerations

- Be careful when approaching any damaged tree.
- Wear a hardhat at all times.
- Keep in mind that branches, which appear to be well wedged in the crown of a tree, can fall without warning and cause serious injury.
- After trees leaf out in the spring, hanging branches will be more difficult to see.
- Do not approach damaged trees that are close to power lines.
- Pruning large branches and stems is difficult and hazardous and should be done only by those trained and experienced in such work.
- Anyone who operates a chainsaw should wear protective clothing and be trained in the safe operation of this equipment.

5.3 Tree Inspections

Inspections for hazard trees can be conducted any time of year, during leaf-on or leaf-off. It is recommended, however, that you inspect trees at both these times to ensure a complete evaluation of damage symptoms.

When identifying trees for inspection, do not confine your survey to trees immediately adjacent to access trails or other high use areas, but extend it back a distance equal to the average tree height in the stand. Inspect areas around buildings and in other places where people may gather, and remove all hazards.

Inspect trees carefully and systematically. Check all parts of tree for defects, including the roots, root or trunk flare, main stem, branches and branch unions. Evaluate tree age and general condition.

5.4 Hazardous Defects

Defects are visible signs that a tree has failed, is failing or has the potential to fail. Defects are common and natural in the forest. Trees with multiple defects will usually pose a more serious hazard than trees with a single defect. The ice storm greatly increased the incidence and severity of defects in both individual trees and stands.

The following discussion and rating of the types and severity of tree defects is taken from Albers and Hayes (1993). The authors identify and discuss seven main types of defect: dead wood, cracks, weak branch unions, decay, cankers, root problems, and poor tree architecture (Table 8).

5.5 Hazard Potential

Numerous factors affect the potential hazard of trees that are found to have one or more of the above defects. These include tree species, tree age and size, tree condition and site conditions. Defect location and number of defects are critical factors to consider.

5.6 Remedial Action

Identification of hazard trees is the first step in providing safe access to a damaged stand. Mark hazard trees with paint or flagging tape to indicate that remedial action is necessary. Reducing the risk of injury or damage can take many forms, including one or more of the following:

- Removing the target.
- Pruning the hazard tree, but restricting pruning to dead, damaged or broken branches.
- Removing the tree.

It is recommended that you be conservative in taking remedial action in the first few years after the ice storm. Remove any hazards, but save other decisions about pruning and removals for later. Some damage may look severe now, but you can usually delay the decision to remove a tree for some time until you are in a position to assess its potential for recov-

Table 8. Hazard potential of trees affected by various defects (Albers and Hayes 1993). Trees with multiple defects may need to be rated at the next higher level.

Defect	Characteristics	Moderate Hazard ¹	High Hazard ²
Crack	- Indicates that a tree is already failing. - A crack is the most serious type of defect. - Severity depends on the depth of the crack, the number of cracks in an area, and the proximity of cracks to other defects.	Hardwood stem has single crack with cavity or decay inside.	- Crack spreads completely through stem. - Stem has two cracks on same segment, with cavity or extensive decay inside. - Stem has crack in contact with another defect or at base of leaning tree. - Branch (> 10 cm) has any type of crack. - Conifer has single crack with in-rolled bark; cavity or decay inside.
Weak Union	- Structurally unsound because bark layers are ingrown (i.e. bark has formed inside the wood or is "included" in the union). - Acute "V-shaped" angles between stems are not as strong as "U-shaped" unions. - Common on trees with a tendency to form upright branches (e.g., elm, ash and maple).	A weak union with included bark.	- A weak union that is also cracked, cankered or decayed. - A weak union in the tree's hot spot³
Decay	- Always results in decreased structural strength and stability. - A tree usually decays from the inside out, eventually forming a cavity. - Caused by fungi, the most dangerous of which are the canker-rot fungi.	Canker-rot infection.	- Canker-rot infection in the tree's hot spot. - Cavity or decay (fruiting body) associated with an open crack or weak branch union. - Any branch with decay. - More serious if decay is advanced (i.e., if wood is soft, punky or crumbly, or there is a cavity in the wood).

Defect	Characteristics	Moderate Hazard ¹	High Hazard ²
Canker	- Caused by mechanical wounding or disease. - Cankers increase the likelihood of stem breakage near the canker, or kill the tree.	- Canker affects more than half the tree's circumference. - Canker at base of leaning tree.	- Canker in tree's hot spot affects more than half the tree's circumference. - Canker-rot infection in tree's hot spot. - Canker physically connected to crack, decay, or weak union.
Root Problems	Problems become apparent only when tree crowns begin to show symptoms (e.g., dieback) or when signs of root failure become obvious (e.g., when fungal fruiting bodies are present).	Root problems associated with stem decay, crack or canker.	- Freshly leaning tree with recent root lifting, soil movement or mounding near base of tree. - Inadequate root support more than half the roots severed inside drip-line.
Poor Tree Architecture	Often caused by storm damage, unusual growing conditions, improper pruning, topping, and other damage.	- Branch unbalanced with respect to rest of crown. - Branches with sharp bend or twist.	- Tree with > 45° lean over target. - Tree leaning over target with another defect in the hot spot.
Dead	Dead trees and large dead branches should be removed immediately.	Branch more than two-thirds dead (remove branch).	- Any dead tree. - Any dead branch or top. - Any lodged branch.

¹ Treating moderate hazard defects is optional, but such defects should be monitored.

² Trees with a high hazard potential should be dealt with as soon as possible.

³ Hot spots are zones approximately one meter above the ground-line up to the lowest branch. Wood within such zones is presumed to be mechanically weaker than the wood above or below.

ery. Many trees that appear to be badly damaged, and hence hazardous, are not as badly damaged as you may think.

6 Monitoring Forest Conditions

Total effects of the 1998 ice storm in eastern Ontario will not be known for several years. Some trees were killed outright. Many more were overturned, badly bent or shattered. Most suffered varying degrees of crown and/or main stem damage. The processes of tree mortality and recovery will take place over many years or decades and will affect future stand structure and dynamics. The forest environment has changed in stands affected by the ice storm. There will likely be further stresses on the stand, both biotic (e.g. insect and disease attack) and abiotic (e.g. drought and additional ice storms) that will influence the rate of tree mortality or recovery.

Effective forest management is based on sound information and knowledge of current stand conditions and expected future yields. Silvicultural prescriptions should be based on forecast growth rates and volume increases that are reasonably predictable over defined timeframes. The 1998 ice storm may or may not have affected these timeframes.

The objective of any monitoring system is to detect and measure changes in the status of the forest over time. It is important that woodlot owners and forest managers be fully aware of the current condition of forest stands affected by the ice storm so that accurate assessments can be made of changes that are likely to occur over the next few years.

6.1 Methodology

Stand assessment methods can be found in Anderson and Rice (1993). These methods will enable the forest manager to estimate species composition, age distribution, wood volumes and merchantability of standing timber. They remain the basis for stand management decisions.

The objective of the following methodology is to provide foresters with guidelines for establishment and assessment of plots for monitoring tree condition using visual features observable from the ground. It is a systematic sampling methodology, a design used in the vast majority of forest surveys. In a systematic sample, the sample units are selected not at random but according to a pre-specified pattern. This approach generally simplifies location of the sample units in the field and reduces costs. The design is based on a methodology described by Innes (1990) with modifications that address the Ontario situation. If plots are re-assessed on an annual or bi-annual basis they will provide the landowner with a measure of tree condition change that can be used to support management decisions.

The sampling methodology suggested for monitoring tree and stand condition uses a cross-cluster configuration of four sub-plots at each of the cardinal points

(north, east, south and west) set at a fixed distance from the plot centre (Appendix D). The plot centres can be set in the permanent plots used to evaluate damage immediately after the 1998 ice storm or at other locations in the stand. The number of plots per woodlot or stand will be determined by several factors including; size of the woodlot, access, cost and resources, variation in stand type, variation in storm damage, and management objectives. Generally more is better.

At each sub-plot, six or ten "closest trees" are assessed depending on whether the plot is in an even-aged stand or in an uneven-aged stand respectively. Each tree is rated and scored on the following features:

- Species
- Diameter class
- Live/dead status
- Crown class
- Crown condition
- Canopy closure
- Epicormic shoots
- Butt and stem damage
- Leader condition in conifers
- Flowering and fruiting
- Insects and disease

Regeneration is also assessed in each sub-plot. A detailed description of the methodology and a sample tally sheet are presented in Appendix C.

6.2 Insects and Diseases

In addition to monitoring general tree condition, landowners should look closely for symptoms of insect and disease activity. Many harmful forest pests target stressed trees for attack. Insect populations and disease infections can build up quickly and spread rapidly throughout damaged stands (Table 9). Additional stress during this critical recovery period on trees already affected by the ice storm could increase the level of depletion through growth loss, crown dieback and tree mortality.

Many excellent insect and disease identification guides are available to the landowner for reference in the field (Section 7.1). This guide does not attempt to cover all the possible pest problems that might arise over the next few years, nor does it go into great detail about these organisms. Instead, a few of the most likely insect and disease problems that landowners might encounter when monitoring tree condition are highlighted.

6.2.1 General considerations

- Ice storms can increase the risk of a pest outbreak by weakening tree defenses.

- In winter trees are dormant, and further injury by insects and diseases is less likely than if the injury occurs during the growing season.
- Uprooted trees are susceptible to stains, decays and invasion by secondary insects.
- Pines are more susceptible to pest outbreaks than hardwoods.
- Pines with major wounds to the lower bole are susceptible to attack by bark beetles.
- Dead and dying trees in a stand are susceptible to attack by wood borers. Although this can be detrimental to the stand, it may also be beneficial, as it can quicken the decomposition of waste material. The circumstances surrounding individual stands will dictate which management options are appropriate.
- Insects and diseases do not usually attack bent hardwoods.
- Stands should be monitored periodically for pest activity and damage.
- Trees that are turning yellow, or those with pitch tubes on the bark or red boring dust around the base, are probably affected by insects and/or diseases.

Table 9. Sequence of invasion by harmful organisms in storm-damaged timber (Barry *et. al.* 1993).

Tree Species	Year 1	Year 2
Pine	Bark beetles, sawyer beetles, blue stain fungi, soft rot fungi	Decay fungi
Oak	Wood borers, stains, soft rot fungi	Sapwood decay fungi
Other hardwoods	Wood borers, *ambrosia beetles, stains, soft rot fungi	Sap and heartwood decay fungi

* Note: Ambrosia beetles are not generally a serious pest problem in eastern Ontario, however, some experts have expressed concern that this insect may become a problem in some stands damaged by the ice storm.

6.3 Key Pests of Conifers

6.3.1 Insects

Pine engraver beetle, <i>Ips pini</i>	
General	Adults are reddish brown to nearly black and are 3.5-4.5 mm long. Posterior end of the abdomen is notched with tooth-like spines. The insect is able to respond rapidly to increased availability of brood material in badly damaged stands. Threat of attack to damaged but standing trees in the spring of the year after an ice storm will be highest in badly damaged stands infested with large populations of pine engraver beetles because overwintering adults will emerge and search for suitable brood material in which to reproduce.
Hosts	Attacks mainly dying or recently dead pines, but sometimes attacks spruces. Occasionally attacks healthy trees when outbreak population levels are present.
Life cycle	Adults overwinter in the duff and emerge in spring. Males cut holes through the bark and construct nuptial chambers in the phloem. Two to four females join the male and each female constructs a separate egg gallery radiating out from the nuptial chamber. Larvae hatch and mine at right angles to the egg galleries, and construct pupal cells at the end of the mine. <i>Ips pini</i> has one or two generations a year, and a generation requires 4-5 weeks to develop. Adults leave the host to overwinter, or to start a second brood, by cutting small, round holes in the bark.
Symptoms	Yellow or reddish boring dust in bark crevices, around entrance holes or on ground. Pitch tubes seldom form. Egg galleries with central nuptial chamber and 2-5 radial tunnels. Galleries free from frass (i.e. boring dust and insect droppings). Foliage discolouration (from green to yellow, reddish, and then reddish brown). Top-killed trees. Discolouration of wood from blue stain fungi.
Damage	Kills tops of older trees: <i>Ips pini</i> often attacks near the top of the trunk and girdles the tree, causing top-kill. Galleries mine bark and score the sapwood. Blue stain reduces value of trees.
Management	Direct control (e.g., by spraying) is not useful. Outbreaks may be prevented by appropriate slash disposal. You can render slash an unsuitable host by scattering it in the open to allow the sun to dry it out.

6.3.2 Diseases

Diseases of roots

Armillaria root rot, *Armillaria ostoyae*

General	Trees damaged by other agents or low-vigour trees are most susceptible to infection. Trees are most commonly infected by root contact with a diseased individual.
Hosts	Jack pine, red pine, and white pine, black spruce and white spruce.
Symptoms	Yellow foliage and branch death in the upper crown. White mycelial fans under the bark. Dark brown to black "shoe-string" structures (rhizomorphs) on the root or in the soil around infected trees. In late summer, clusters of honey-coloured mushrooms form around the base and over the roots of infected trees. Mushroom caps are 5-12.5 cm in diameter and have dark scales on the upper surface and yellowish-white gills on the undersurface.
Damage	Growth loss. Death as a result of girdling at the root collar or death of the major roots. More likely to cause mortality in younger trees than in older trees because the disease progresses more rapidly in the former. A weakened root system makes trees susceptible to windthrow.
Management	You can determine the distribution of <i>Armillaria</i> and its potential for damaging a stand by assessing current damage in the stand. Gaps filled with younger woody species indicate early mortality. Randomly oriented dead trees broken off at ground level indicate newer centres of <i>Armillaria</i> infection. You should remove roots — particularly large, infected roots — in these areas and several metres beyond. Managing other stress-inducing agents will reduce susceptibility to <i>Armillaria</i> .

Note:

- Stands affected by *Armillaria* root rot, whether symptoms are apparent or not, may experience an increase in *Armillaria* activity after tree crowns are damaged.
- Avoid any action, such as cutting that will provide *Armillaria* with more favourable conditions (dead stumps and roots).
- Give the trees time to recover before removing dead or failing trees.

Fomes root rot, <i>Heterobasidion annosum</i>	
General	Usually attacks trees in previously thinned conifer plantations. Airborne spores colonize freshly cut stump surfaces or wounds and the disease spreads through root-to-root contact.
Hosts	Mainly pines.
Symptoms	Circular patches of dead trees. Thin, discoloured foliage. Weakened root systems cause trees to lean. Fruiting bodies may be concealed in the litter at the base of dead or dying trees. In the final stages of the disease, white spongy pocket rot produced in the roots and butt.
Damage	Volume loss. Reduced growth and mortality. Infected trees are susceptible to windthrow and other pests.
Management	Treat fresh-cut stump surfaces with fungicides that are currently registered for control of this disease. If possible, disrupt root contact among adjacent trees.

Diseases of stems and branches

Stem decay

General	Infection occurs at wounds, dead branches, dead tops or branch stubs. Trees with reduced vigour are more susceptible to infection
Hosts	Mainly pines.
Examples of fungi that cause stem decay of conifers	Red belt fungus (<i>Fomitopsis pinicola</i>). Bleeding fungus (<i>Stereum sanguinolentum</i>). Red ring rot (<i>Phellinus pini</i>).
Symptoms	Fruiting bodies (e.g. mushrooms, conks, etc.) on the outside of infected trees indicate internal decay. Internal symptoms will vary depending on species of fungus. Rot colour in early stages is highly variable; rot colour in final stages will be either brown or white depending on the species of fungus. Rot texture will generally be either stringy (white rot) or cubical (brown rot), depending on the species of fungus.
Damage	Decay fungi destroy heart and sapwood, decreasing the value of trees. Staining of wood decreases value. Wood with extensive decay can lose all of its structural strength and be susceptible to windthrow. Damage caused by decay fungi increases with the age of trees.
Management	Removal of trees with conks or large wounds will help to minimize losses due to decay. Silvicultural activities that increase growth and reduce competition can help to reduce decay. The simplest control is to harvest before levels of decay become unacceptable.

6.4 Key pests of Hardwoods

6.4.1 Insects

Bronze birch borer, *Agrilus anxius*

General	Probably the most destructive pest of birch in North America. Larvae are flat, creamy white, legless grubs with light brown heads, segmented bodies, laterally expanded thoraxes and two dark brown dorsal spines at the posterior end of the abdomen. Mature larvae are 35 mm long. Adults are olive-green to black with metallic-bronze reflections, slender, and 6-11 mm long.
Hosts	Birches, oaks and aspen. Attacks mainly weakened trees, although populations can build up and attack apparently healthy trees. Trees showing initial signs of decline are at high risk.
Life cycle	Larvae overwinter in feeding tunnels in the wood. Pupation occurs in the spring and adults begin to emerge in June. Adults feed on leaves of the host tree, but do not cause significant damage. After mating, they lay eggs, singly or in small groups, under bark scales or in bark crevices on the sunny side of open-growing trees. Eggs hatch about 2 weeks later, and the larvae construct meandering tunnels through the bark to the wood surface. Larvae develop through five instars, periodically entering the wood to molt and then to overwinter. The life cycle can take 1 or 2 years, depending on the geographic location.
Symptoms	Chlorotic leaves and sparse foliage in the upper crown. D-shaped adult emergence holes, 3-4 mm in diameter, in the bark of dying or dead portions of stems and branches beginning in June. Long, meandering, frass-packed galleries in the phloem and cambium (Note: You must remove bark to confirm the presence of larvae because they do not expel frass or sap). Feeding tunnels in healthy tissues are generally unsuccessful. They heal over and form callus tissue, giving the bark a bumpy appearance.
Damage	Larval tunnels partially girdle stems and branches, contributing to the decline and death of trees. The degree of injury will depend on the distribution and density of successful larval galleries. Repeated attacks can kill trees.
Management	You can prevent damage by wood borers that attack dying or recently felled trees by removing such host materials quickly.

Sugar maple borer, *Glycobius speciosus*

General	Breeds in living hosts. Adults are velvety black and 19-28 mm long. Larvae can be 50 mm long.
Hosts	Sugar maple.
Life cycle	Eggs are laid on the stem near wounds in mid-summer. Larvae hatch and feed extensively at the wood surface. They overwinter at the wood surface and resume feeding in the following year. In spring, the larvae bore deep into the wood, and construct a pupal cell. The adults emerge through exit holes in early summer.
Symptoms	Sawdust produced while larvae cut out emergence holes accumulates at the bottom of infested trees.
Damage	Damage most severe to trees growing in open stands. Extensive larval tunnels in the sapwood cause the covering bark to die and become cracked or swollen. Bark breaks off old wounds, exposing larval tunnels. May weaken and kill the host or cause defects and stains that seriously reduce lumber value.
Management	You can reduce losses by removing and burning infested dead limbs and trees before adult emergence in spring.

6.4.2 Diseases

Diseases of roots

Armillaria root rot, *Armillaria* spp.

General	Trees damaged by other agents or low-vigour trees are most susceptible to infection. Trees are most commonly infected by root contact with a diseased individual.
Hosts	Oak, maple and aspen.
Symptoms	Yellow foliage and branch death in the upper crown. White mycelial fans under the bark. Dark brown to black "shoe-string" structures (rhizomorphs) on the root or in the soil around infected trees. In late summer, clusters of honey-coloured mushrooms form around the base and over the roots of infected trees. Mushroom caps are 5-12.5 cm in diameter and have dark scales on the upper surface and yellowish-white gills on the undersurface.
Damage	Growth loss. Death as a result of girdling at the root collar or death of the major roots. More likely to cause mortality in younger trees than in older trees because the disease progresses more rapidly in the former. A weakened root system makes trees susceptible to windthrow.
Management	You can determine the distribution of <i>Armillaria</i> and its potential for damaging a stand by assessing current damage in the stand. Gaps filled with younger woody species indicate early mortality. Randomly oriented dead trees broken off at ground level indicate newer centres of <i>Armillaria</i> infection. You should remove roots — particularly large, infected roots — in these areas and several metres beyond. Managing other stress-inducing agents will reduce susceptibility to <i>Armillaria</i> .

Note:

- Stands affected by *Armillaria* root rot, whether symptoms are apparent or not, may experience an increase in *Armillaria* activity after tree crowns are damaged.
- Avoid any action, such as cutting that will provide *Armillaria* with more favourable conditions (dead stumps and roots).
- Give the trees time to recover before removing dead or failing trees.

Diseases of stems and branches

Stem decay

General	Infection occurs at wounds, dead branches, dead tops or branch stubs. Trees with reduced vigour are more susceptible to infection.
Examples of fungi that cause stem decay of hardwoods	Canker rot (<i>Cerrena unicolor</i>). False tinder conk (<i>Phellinus tremulae</i>). Artist's conk (<i>Ganoderma applanatum</i>). Tinder conk (<i>Fomes fomentarius</i>).
Symptoms	Fruiting bodies (e.g. mushrooms, conks, etc.) on the outside of infected trees indicate internal decay. Internal symptoms will vary depending on species of fungus. Rot colour in early stages is highly variable; rot colour in final stages will be either brown or white depending on the species of fungus. Rot texture will generally be either stringy (white rot) or cubical (brown rot), depending on the species of fungus.
Damage	Decay fungi destroy heart and sapwood, decreasing the value of trees. Staining of wood decreases value. Wood with extensive decay can lose all of its structural strength and be susceptible to windthrow. Damage caused by decay fungi increases with the age of trees.
Management	Removal of trees with conks or large wounds will help to minimize losses due to decay. Silvicultural activities that increase growth and reduce competition can help to reduce decay. The simplest control is to harvest before levels of decay become unacceptable.

6.5 Key Pests of Cedars

- Two or more species of sawflies feed on the foliage of cedars, but they rarely cause significant damage. Many wood borers feed on cedar (e.g. the cedar tree borer, *Semanotus ligneus*), but the damage is generally not significant.
- The cedar leaf miners are common pests of cedars in eastern Canada. Stress caused by the ice storm may make trees more susceptible to attack by cedar leaf miners. Feeding by cedar leaf miners can cause foliage scorching in the spring and subsequent twig, branch or tree mortality.

6.6 Other Pests to Monitor

Trees that survived the 1998 ice storm will be in a weakened state for several years and will be particularly vulnerable to attack by other forest pests such as the **gypsy moth**, *Lymantria dispar*, and **forest tent caterpillar**, *Malacosoma disstria*. Outbreaks of these defoliators could put additional stress on already stressed trees. Landowners and forest managers should monitor stands for signs of these pests. Protection programs can be carried out to reduce defoliation and stress on surviving trees.

Reference material for insect and disease identification is presented in section 7.1.

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Distribution Centre (Write for current price - about \$10 U.S. each)
7 Research Park
Cornell University
Ithaca, NY 14850

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8 Appendices

- **A – Stand stocking diagram**
- **B – Tree species and abbreviations**
- **C – Silvical characteristics of tolerant hardwoods**
- **D – Tree condition monitoring**
- **E – Glossary of terms**
- **F – Other contacts**

Appendix A

8.1 How To Use A Stocking Guide (OMNR 1998a)

Stocking guides are decision support tools used in even-aged hardwood management to show the relationship between the number of trees and basal area, stocking per cent and quadratic mean diameter for trees in the stand. These guides provide an assessment of the stand's use of available growing space and suggests when growing space is limited and thinnings should be considered to meet management objectives (usually this means to maintain optimum growth).

When using a stocking guide make sure that you are using one that is most appropriate for your stand condition. Species and site factors influence the development of local stocking guides. APPENDIX D provides examples of stocking guides that are appropriate for most species in Ontario. Where stocking guides have not been created for an individual species or where local site conditions are different from where the stocking guide was created, it is recommended that those developed by Leak *et al.* (1987) or Tubbs (1977b) be used.

Stocking guides are simply graphs with the number of trees per area on the X-axis and basal area per area on the Y-axis (*see* FIGURE 7.5.1). On the graph there are also 2 series of lines that show the quadratic mean diameter for trees in the stand and the level of stocking. Stocking levels are usually presented as "A", "B", and "C" lines. The "A" line represents the normal condition of maximum stocking for undisturbed stands of average structure. At this line the stand is fully utilizing or occupying the site. The "B" line is the lower limit of stocking needed for full occupancy of the site. This is where crowns are fully developed and are just touching each other. In general for tolerant hardwoods, the "B" is approximately 58 per cent of the "A" line level. Stands at "C"-level stocking are expected to reach the "B" level within 10 years (Gingrich 1967).

The number of trees and basal area per hectare is needed to use a stocking guide. Stand stocking level and quadratic mean diameter are determined by the intersection of stand density and basal area. From this location the crown cover can be determined.

When stocking is at the "A" level, the stand is fully stocked and growing space is fully utilized. If it is above the "A" level, growing space is over-utilized and there will be mortality and self-thinning. In this condition, individual tree and stand growth is low and individual tree mortality offsets growth to keep stocking at the "A"-level. Growing space is also fully utilized between "A"- and "B"-level stocking. Stands grow, but growth on individual trees varies greatly. Below "B"-level stocking, growing space is not fully utilized and optimum use of the resources does not occur.

Thinning is recommended in stands that are at or above the "A"-level. Individual tree growth is highest when the stand is thinned to the "B"-level. In thinning the

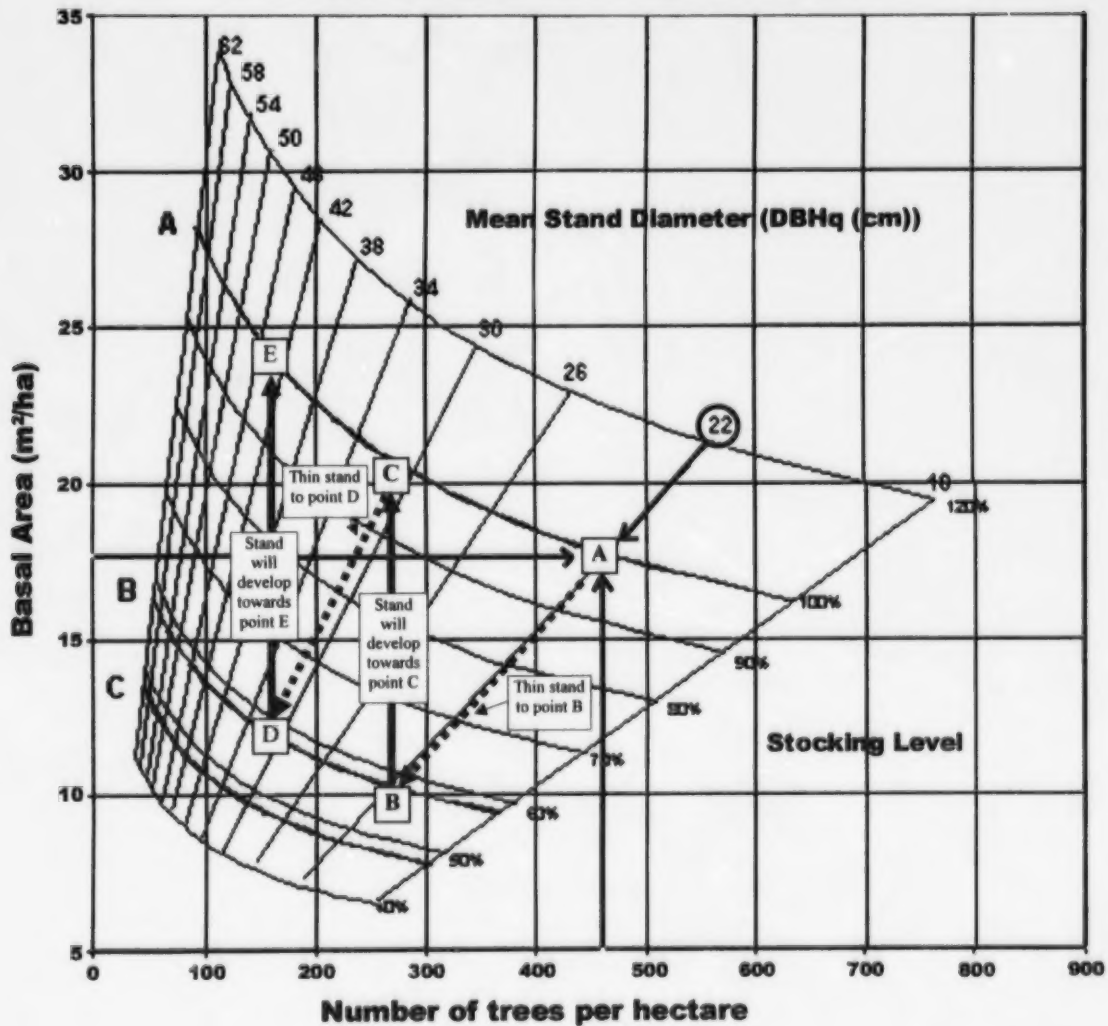
stand, the number of trees and basal area will be lowered, but the quadratic mean diameter of the stand should remain roughly the same or increase if thinning removes the smaller diameter trees. Changes in stand conditions can be projected by moving down the appropriate quadratic mean diameter line to the post harvest density level. Growth can be predicted by moving the stand parallel to the Y-axis. (i.e. the number of trees remains the same, but as trees grow the basal area will increase). Thinning should be scheduled again when stands reach the "A"-level, if maximizing tree growth is a main objective.

Thinning stands between the "A"- and "B"-levels, to the "B"-level may increase individual tree growth but at the expense of overall stand growth. Thinning in this zone is done to meet non-timber management objectives.

Stands below the "B"-level should not be thinned.

In the example shown below the current stand condition is identified at point A. It is positioned at the 100% stocking level ("A" line). At this level a thinning is prescribed. The stand is thinned to position B (the "B" line). This lowers the basal area and the number of trees by maintaining the mean stand diameter (DBHq). Trees remaining in the stand at point B will grow to point C (100% stocking level). This process is repeated again where trees are thinned from point C to point D. Trees remaining grow from point D to point E.

Example application of a stocking guide



Note: For even-aged management of hardwoods.

SUMMARY TABLE			
Point	Basal Area (m ² /ha)	Number of trees/ha	DBHq (cm)
A	18	475	22
B	11	280	22
C	21	280	31
D	12	160	31
E	24	160	44

Appendix B

8.2 Tree Species Abbreviations

Tree Species		Abbreviation
black ash	<i>Fraxinus nigra</i> Marsh.	Ab
green ash	<i>Fraxinus pennsylvanica</i> var. <i>lanceolata</i> (Borkh.) Sarg.	Ag
white ash	<i>Fraxinus americana</i> L.	Aw
basswood	<i>Tilia americana</i> L.	Bd
American beech	<i>Fagus grandifolia</i> Ehrh.	Be
balsam fir	<i>Abies balsamea</i> (L.) Mill.	Bf
white birch	<i>Betula papyrifera</i> Marsh.	Bw
yellow birch	<i>Betula alleghaniensis</i> Britton (Betula lutea Michx. F.)	By
black cherry	<i>Prunus serotina</i> Ehrh.	Cb
eastern white cedar	<i>Thuja occidentalis</i> L.	Cw
American elm	<i>Ulmus americana</i> L.	Ea
eastern hemlock	<i>Tsuga canadensis</i> (L.) Carr.	He
ironwood	<i>Carpinus caroliniana</i> Walt.	Id
sugar maple	<i>Acer saccharum</i> Marsh.	Mh
red maple	<i>Acer rubrum</i> L.	Mr
silver maple	<i>Acer saccharinum</i> L.	Ms
red oak	<i>Quercus rubra</i> L.	Or
white oak	<i>Quercus alba</i> L.	Ow
jack pine	<i>Pinus banksiana</i> Lamb.	Pj
trembling aspen	<i>Populus tremuloides</i> Michx.	Pt
largetooth aspen	<i>Populus grandidentata</i> Michx.	Pl
balsam poplar	<i>Populus balsamifera</i> L.	Pb
white pine	<i>Pinus albicaulis</i> Engelm.	Pw
red pine	<i>Pinus resinosa</i> Ait.	Pr
black spruce	<i>Pinus mariana</i> (Mill.) B.S.P.	Sb
white spruce	<i>Picea glauca</i> (Moench) Voss	Sw
red spruce	<i>Picea rubens</i> Sarg.	Sr
tamarack	<i>Larix laricina</i> (Du Roi) K. Koch	La
black walnut	<i>Juglans nigra</i> L.	Wb

Appendix C

8.3 Silvical Characteristics of Tolerant Hardwoods

Species of Tolerant Hardwoods							
Silvical Character	Hard Maple	Beech	Yellow Birch	Hemlock	Red Oak	White Ash	Black Cherry
Age Structure	Uneven/Even	Uneven/Even	Even (Mosaic)	Uneven/Even	Even	Even (Mosaic)	Even
Sprouting Ability	Good	Root Suckers	Poor	Very Poor	Very Good	Good	Moderate
Shade Tolerance	Very tolerant	Tolerant	Intermediate	Tolerant	Intermediate	Intermediate	Intolerant
Response to Release	Good	Moderate	Moderate	Good	Good	Good	Poor
Rot/Stain Defect	High	High	High	Low	Mod./Low	Low	Moderate
Bole/Form Defect	Fork	Epicormics	Fork	Shake	Epicormics	Fork	Sweep

Appendix D

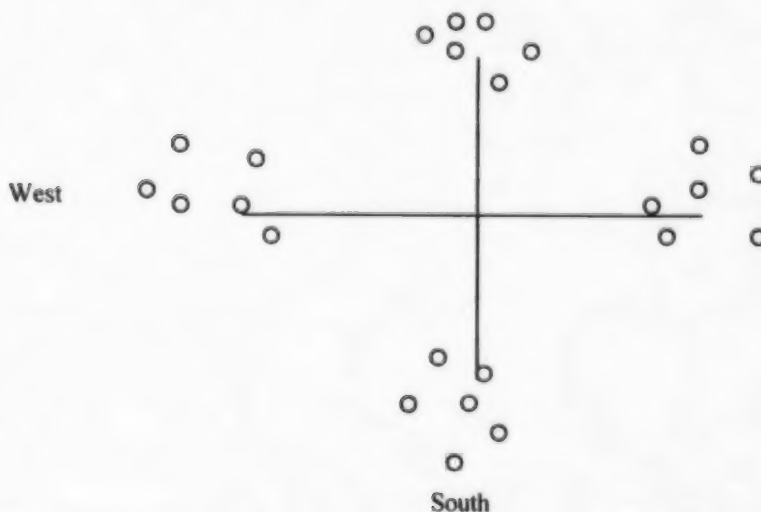
8.4 Forest Monitoring Instructions

Supplies needed: clipboard, tally sheets, flagging tape, 2m²/ha B.A.F. prism, calipers, map or air photo

1. Divide property into compartments on map or aerial photo, number compartments.
2. Establish a minimum of one monitoring plot (cluster of four sub-plots) in each compartment.
3. Locate the plot centre well into the stand.
4. Use the spaces on the field sheet to indicate the forest type and details of the compartment.
5. Follow procedure outlined below to assess the compartment.
6. Mark each assessed tree with flagging tape to facilitate future monitoring of the same trees.

Plot Layout:

Locate the centre of the monitoring plot and mark it with flagging or paint for future reference. Each of the four sub-plots is located 25 meters from the plot centre to the north, south, east, and west. The centre of each sub-plot should be flagged or painted. Examine the recommended number of trees closest to the sub-plot centre.



Number of Trees Assessed:

- In plantations and even-aged stands assess **6** trees per sub-plot (**Total = 24**)
- In uneven-aged stands assess **10** trees per sub-plot (**Total = 40**).

Tree Assessment Codes:

Diameter Class:

- 1 – 10-24 cm Polewood
- 2 – 26-40 cm Small sawtimber
- 3 – 42-48 cm Medium sawtimber
- 4 – 50+ cm Large sawtimber

Live/Dead Status:

- 1 – Live
- 2 – Dead

Crown Class:

- 1 – Dominant
- 2 – Codominant
- 3 – Intermediate
- 4 – Suppressed

Crown Condition:

Code	Hardwoods	Conifers
0	No visible crown damage, full complement of foliage.	No viable crown damage, full complement of foliage.
1	Branches missing, or dead branches and bare twigs in <25% of the crown.	A few scattered broken branches, no damage to the main stem.
2	Branches missing, or dead branches and bare twigs in 25-50% of the crown.	Main stem broken in upper 1/3 of crown or dead branches and twigs in 1/3 of crown.
3	Branches missing, or dead branches and bare twigs in 51-75% of the crown.	Main stem broken in mid 1/3 of crown, or dead branches and twigs in 2/3 of crown.
4	Branches missing, or dead branches and bare twigs in >75% of the crown.	Less than 3 live branches.
5	Tree died since last assessment	Tree died since last assessment

Canopy Closure:

- 0 – crown open-grown or with no contact with surrounding trees
- 1 – crown in contact with others on one side
- 2 – crown in contact with others on two sides
- 3 – crown in contact with others on three sides
- 4 – crown in contact with others on four sides

Epicormic Shoots On the Trunk and in the Crown

- 1 – rare
- 2 – scattered (11-50 on the stem or main branches)
- 3 – common (51-100 on the stem or several main branches)
- 4 – abundant (stem or main branches obscured by epicormics)

Butt and Stem Damage:

- 1 – dead area with bark still present
- 2 – area of exposed wood
- 3 – resin or sap flow from cracks or holes
- 4 – swelling covering previous damage
- 5 – crack at least 5 times long as wide
- 6 – fungus, i.e. a visible fruiting body on the stem
- 7 – animal damage
- 8 – fire damage

Leader Condition on Conifers: (Optional if visible from ground))

- 1 – shorter than current-year side shoots
- 2 – missing
- 3 – bent or twisted
- 4 – double
- 5 – broken
- 6 – bare
- 7 – side shoots taken over apical dominance

Flowering in Pine: (Optional)

- 1 – rare, 1-10% of branches
- 2 – infrequent, 11-25% of branches
- 3 – common, 26-60% of branches
- 4 – abundant, > 60% of branches

Fruiting: (Optional)

- 0 – none
- 1 – scarce
- 2 – common
- 3 – abundant

Insect or Disease Damage

0 - No damage.

1 - Evidence of wood borer or bark beetle activity.

2 - Evidence of defoliator activity (e.g. gypsy moth, spruce budworm etc.)

3 - Other symptom, e.g. off-colour or dead foliage, small leaves.

Regeneration Survey:

An assessment of regeneration should be conducted within the area of each sub-plot using the criteria provided on the field tally sheet.

Comments:

Use the **Comments** section to record any significant signs of insect, disease or abiotic damage, any special wildlife sighting (including mortality), and any wildlife features observed on the property. (e.g. nesting activity of raptors or other birds of prey, sightings or signs of wild turkey, Hungarian partridge, fisher etc). Make a note of the tree number if a wildlife feature is located within the sub-plot.

Post Ice Storm Tree Condition Assessment Field Sheet

Date: _____

Landowner: _____ Twp: _____ Lot: _____ Conc: _____ Compartment: _____

Area (Woodlot): _____ ha Area (Compartment): _____ ha Assessor: _____

Forest Types: Plantation: Young (> 3m) _____ Maturing _____ Mature (> 15cm dbh) _____

Woodlot: Woodlot: Young (< 10cm dbh) _____ > 10cm dbh _____ Mixed _____ Coniferous _____

Tree no. & species	Diam. Class	Live/Dead	Crown Class	Crown Cond.	Canopy Closure	Trunk	Epicormics	Butt & Stem	Leader	Flowering	Fruiting	Insect or Disease
N-1												
N-2												
N-3												
N-4												
N-5												
N-6												
N-7												
N-8												
N-9												
N-10												
E-1												
E-2												
E-3												
E-4												
E-5												
E-6												
E-7												
E-8												
E-9												
E-10												
S-1												
S-2												
S-3												
S-4												
S-5												

Tree no. & species	Diam. Class	Live/Dead	Crown Class	Crown Cond.	Canopy Closure	Epicomics	Leader Conifer	Flowering	Fruiting	Insect or Disease
S-6						Trunk				
S-7										
S-8										
S-9										
S-10										
W-1										
W-2										
W-3										
W-4										
W-5										
W-6										
W-7										
W-8										
W-9										
W-10										

Comments

Regeneration Survey

Sub-plot	N	E	S	W
Quantity				
Dist.				
Size				
Species				

Codes:

Quantity	Distribution	Size
1 - little (< 10%)	1 - scattered	1 - seedling
2 - some (11-30%)	2 - uniform	2 - advanced
3 - ample (31-60%)	3 - patchy	
4 - heavy (> 60%)		

Appendix E

8.5 Glossary of Terms

A

abiotic factors. The non-living components of the environment, such as air, rocks, soil, water, peat and plant litter.

advanced regeneration. Trees that have become established naturally under a mature forest canopy and are capable of becoming the next crop after the mature crop is removed.

adventitious. Arising from unusual positions, as in buds on roots.

AGS - acceptable growing stock. Trees suitable for retention in the stand for at least one cutting cycle (15 to 25 years). They are trees of commercial species and of such form and quality as to be salable for sawlog products at some future date. The designation itself is not a cut/residual decision. Some AGS will be cut in a stand, as will some UGS be left as residuals.

basal area.

- *of a tree:*
 - the cross-sectional area of the bole of a tree, 1.3 metres above the ground. Basal area = diameter of tree (cm) squared, times 0.00007854. (Expressed in square metres).
- *of a stand of trees:*
 - the sum of all the individual tree basal areas for a given land area.
 - Commonly expressed as square metres per hectare.

bear's nest. An abiotic defect in mast trees formed when animals break off branches in order to reach mast. Host trees are weakened due to loss of crown.

biodiversity - biological diversity. The variety and variability (in time and space) among living organisms and the ecological complexes in which they occur.

blowdown (windthrow). Uprooting by the wind. Also refers to a tree or trees so uprooted.

bole. The main trunk of a tree.

breast height. The standard height, 1.3 m above ground level, at which diameter of a standing tree is measured.

browse. Small bushes, sprouts, herbaceous plants, small trees, etc. that wildlife feed on.

butt. The base of a tree or log.

C

canker. Dead area of a branch or stem caused by fungal or bacterial attack.

canopy. A collective term for the layer formed by the crowns of the taller trees in a forest.

canopy closure. The progressive reduction of space between crowns as they spread laterally, increasing canopy cover.

cavity. An unfilled space within a mass, a hollowed out space. In forestry and wildlife there are several categories of cavity trees, each with their own importance in the ecosystem:

clearcut. An area on which the entire timber stand has been harvested. *see reproduction clone.* All plants reproduced asexually from a common ancestor and having identical genotypes. (genetically identical to the parent plant) (e.g. from cuttings or suckers).

coarse woody debris (CWD). Sound and rotting logs and stumps that provide habitat for plants, animals and insects and a source of nutrients for soil development.

codominant trees. Trees with crowns forming the general level of the crown cover and receiving full light from above, but comparatively little from the sides; usually with medium size crowns. *see crown class.*

competition. The general struggle for existence within a trophic level in which the living organisms compete for a limited supply of the necessities of life.

composition. The representation of tree species in a forest stand, expressed quantitatively as per cent by volume or basal area of each species.

conifer. A tree belonging to the order Coniferae, usually evergreen with cones, needle-shaped leaves and producing wood known commercially as 'softwood.'

coppice. A shoot (sprout) originating from a stump

cover. Vegetation or other material providing protection. Plants or objects used by wild animals for nesting, rearing of young, resting, escape from predators, or protection from adverse environmental conditions.

critical wildlife habitat. Part or all of a specific place occupied by a wildlife species or a population of such species and recognized as being essential for the maintenance of the population.

crook. A defect in logs and poles or pilings, consisting of an abrupt bend. Also refers to edgewise warp in a piece of lumber.

crop tree. A tree selected in a young stand, to be retained until final harvest.

crotch. The fork of a tree or branch.

crown. The branches and foliage of a tree.

crown class. A designation of trees in a forest with crowns of similar development and occupying similar positions in the crown cover. Differentiation into crown classes applies to even-aged stands and within small even-aged groups in which trees in an uneven-aged stand are often arranged. Five crown classes are commonly recognized: dominant, codominant, intermediate, overtopped (suppressed), and wolf trees.

crown closure. The time at which the available crown space has become fully occupied.

crown cover. The canopy of green leaves and branches formed by the crowns of all trees in a forest. Generally expressed as a per cent of total area.

crown density. The compactness of the crown cover of the forest; depends on the distance apart and the compactness of the individual crowns. A loose term combining the meanings of 'crown closure' and 'shade density.'

cubic metre. A volume measure, one metre by one metre by one metre.

cutting cycle. The planned interval between major harvesting operations in the same stand. A 20-year cutting cycle indicates a harvest is done once every 20 years.

D

Dark-face basal wound. Usually a ground-contact wound that is grey-black in appearance, moist, with a somewhat spongy surface.

DBH - diameter at breast height. The diameter of a tree outside of the bark at roughly breast height. Normally measured 1.3 metres off the ground on the uphill side of the tree. It is easier to measure at this height and many trees have large swells in the stem below this point that could increase errors in computing tree volumes.

defect. Any irregularity or imperfection in a tree, log, piece, product, or lumber that reduces the volume of sound wood or lowers its durability, strength, or utility value.

defoliator. An agent that damages trees by destroying leaves or needles.

den tree. A tree having a hollow or cavity used by animals for refuge or hibernation.

dominant trees. Trees with crowns extending above the general level of the crown cover and receiving full light from above and partly from the side; larger than the average trees in the stand, with crowns well developed, possibly somewhat crowded on the sides. *see crown class.*

dry rot. A decay of the "brown rot" type, caused by specialized fungi capable of conducting moisture from an available source and extending their attack to wood previously too dry to decay. Found chiefly in buildings. The term is open to the misinterpretation that wood will rot when dry, which is not true.

E

ecosystem. A functional unit consisting of all the living organisms (plants, animals and microbes) in a given area, and all the non-living physical and chemical factors of their environment, linked together through nutrient cycling and energy flow. An ecosystem can be of any size—a log, pond, field, forest, or the earth's biosphere—but it always functions as a whole unit. Ecosystems are commonly described according to the major type of vegetation, for example, forest ecosystem, old-growth ecosystem, or wetland ecosystem.

ecosystem management. The use of an ecological approach to achieve productive resource management by blending social, physical, economic and biological needs and values to provide healthy ecosystems.

edge. The transitional zone where one cover type ends and another begins.

environment. All elements, living and inanimate, that affect a living organism.

epicormic sprout. A branch rising spontaneously from an adventitious or dormant bud on the stem or branch of a woody plant.

epidemic. Widespread insect or disease incidence beyond normal proportions; usually accompanied by excessive damage.

even-aged. The conditions of a forest or stand composed of trees having no, or relatively small, differences in age, although differences of as much as 30 per cent are admissible in rotations greater than 100 years of age.

even-aged management. The application of a combination of actions that results in the creation of stands in which trees of essentially the same age grow together. The difference in age between trees forming the main canopy level of a stand usually does not exceed 20 per cent of the age of the stand at maturity. Regeneration in a particular stand is obtained during a short period at or near the time that a stand has reached the desired age or size for regeneration and is harvested. Cutting methods producing even-aged stands are clearcut, shelterwood, or seed-tree.

F

forest. A plant community predominantly of trees and other woody vegetation, growing more or less closely together. An area managed for the production of timber and other forest products, or maintained under woody vegetation for such indirect benefits as protection of site or for recreation.

forest management. The application of business methods and technical forest principles to the management of forest property.

forest protection. The activities connected with the prevention and control of damage to forests from fire, insects, disease and other injurious and destructive sources.

forest site. A land unit characterized by climate, soil and topographic features that control forest type and growth.

forest survey. An inventory of forest land to determine size, condition, timber volume and species, for specific purposes or as a basis for forest policies and programs. Also refers to carefully measuring and marking property boundaries.

forest type. A descriptive term used to group stands of similar character in composition and development, to differentiate them from other groups of stands.

fungus. A plant without chlorophyll that derives its nourishment from the organic matter of other plants.

G

genetic diversity. Variation among and within species that is attributable to differences in hereditary material.

glaze damage. Damage to tree caused by ice or frost.

group selection. Modification of the selection system in which trees are removed in small groups rather than as individuals.

growing stock. The sum, by number or volume, of all the trees in a forest or a specified part of it.

growth. The increase in diameter, basal area, height or volume of individual trees or groups of trees during a given period.

growth rate. With reference to wood, the rate at which wood has been added to the tree at any particular point, usually expressed in the number of annual rings per centimetre. May also be stated as "annual leader growth."

H

habitat. The environment in which the plant or animal lives.

hardwood.

- Generally, one of the botanical group of trees that have broad leaves, in contrast to the needle-bearing conifers.
- Wood produced by broad-leaved trees, regardless of texture or density.

harvest. Extraction of some type of product from the forest. Generally associated with a cutting.

heart rot. A decay characteristically confined to the heartwood. It usually originates in the living tree.

heartwood. The inner core of a woody stem, wholly composed of non-living cells and usually differentiated from the outer enveloping layer (sapwood) by its darker colour.

hectare. An area measure of 10,000 square metres. Basic unit of land area.

I

ice damage. Breakage of tops and branches and stripping of branches and needles by an ice storm.

immature. Trees or stands that have grown past the regeneration stage, but are not yet mature.

improvement cutting. The elimination or suppression of less valuable trees in favour of more valuable trees, typically in a mixed, uneven-aged forest.

intermediate trees. Trees shorter than those in the dominant or codominant classes, but with crowns either below or extending into the crown cover formed by codominant and dominant trees; receiving a little direct light from above, but none from the sides; usually with small crowns, considerably crowded on the sides. *see crown class.*

intolerance. Trees unable to survive or grow satisfactorily under specific conditions, most commonly used with respect to their sensitivity to shade but also to conditions such as wind, drought, salt and flooding.

L

layering. The rooting of an undetached branch, lying on or partially buried in the soil or other forest floor media, that is capable of independent growth after separation from the parent plant.

leader. The growing top (terminal shoot) of a tree. The distance up the main stem of the tree between each whorl of branches generally represents one year of height growth.

leave tree. Tree left in or just outside a harvest zone (often otherwise a clearcut) to re-seed the area. This is nature's method of reforestation; but it is often slower and it does not have the more assured results of direct seeding or planting. May also refer to trees left after a thinning.

log rule. A table showing the estimated or calculated amount of lumber that can be sawn from logs of given length and diameter.

M

management plan. A written plan for the organized handling and operation of a forest property. It usually includes data and prescribes measures designed to provide optimum use of forest resources according to the landowner's objectives.

marking timber. Selecting and indicating, usually by a paint mark, trees to be cut or retained in a harvesting or tending operation.

mast. The fruit and nuts of trees and woody shrubs used as a food source by wildlife.

mast trees. Trees supporting mast production, e.g. oak, beech, cherry.

maturity. For a given species or stand, the approximate age or condition beyond which the growth rate declines or decay begins to assume economic importance.

mortality. Death of forest trees as a result of competition, disease, insect damage, drought, wind, fire and other factors.

multiple-use. A system of resource use where the resources in a given land unit serve more than one user. Multiple use can be effected in three ways:

- different uses of adjacent sub-areas which together form a composite multiple use area;
- the alternation in time of different uses on the same areas; and
- more than one use of an area at one time.

In multiple use planning, where differing resource uses are conducted at the same time on the same area and conflicts between users will occur, one resource is determined to be the dominant use and all other secondary uses are integrated only in-so-far as they are compatible with the first. Often multiple use planning sacrifices the production of the individual resources in favour of the over-all mix of resource uses that brings the greatest social and economic benefits.

N

natural regeneration. The renewal of a forest stand by natural seeding, sprouting, suckering, or layering seeds may be deposited by wind, birds or mammals.

natural thinning. Death of trees in a stand as a result of competition.

O

overstocked. A condition of the stand or forest, indicating more trees than desired, normal, or full stocking would require.

overstory. That portion of the trees in a stand forming the upper crown cover.

P

pest. A plant, animal, or thing that is troublesome or annoying (from a human value perspective).

plantation. An artificially reforested area established by planting or by direct seeding

plot. A carefully measured area laid out for experimentation or of mensuration; may be permanent or temporary.

prescription. A course of management action prescribed for a particular area after specific assessments and evaluations have been made

pruning. The removal of live or dead branches from standing trees, usually the lower branches of young trees and the removal of multiple leaders in plantation trees, for the improvement of the tree or its timber; the cutting away of superfluous growth, including roots, from any plant to improve its development.

punky. A soft, weak, often spongy condition in wood; caused by decay.

R

regeneration. The renewal of a tree crop whether by natural or artificial means. Also the young crop itself which commonly is referred to as reproduction.

release. Freeing a tree or group of trees from competition by cutting or otherwise eliminating growth that is overtopping or closely surrounding them.

reproduction methods.

- **clearcutting:** Removal of the entire forest in one cut. This method perpetuates even-aged stands.
- **seed-tree:** Removal of the mature timber in one cut, except for a small number of seed trees; called a group cutting when the seed trees are left in groups, a reserve cutting when specifically selected seed trees are left for growth, as well as to furnish seed.
- **selection:** Removal of mature timber, usually the oldest or largest trees, either as single scattered trees or in small groups at relatively short intervals, commonly 15 to 25 years, repeated indefinitely. This encourages a continuous establishment of natural reproduction and an uneven-aged stand is maintained.
- **shelterwood:** Removal of the mature timber in a series of cuttings, which extend over a period of years. Usually equal to not more than one-quarter (often not more than one-tenth) of the time required to grow the crop. The establishment of natural reproduction under the partial shelter of seed trees is encouraged, but sometimes these areas must be artificially regenerated.

- **coppice:** Forest regeneration by sprouting (vegetative reproduction) from stumps or roots.

residual basal area. The basal area per hectare of acceptable trees left standing after harvest.

residual stand. Trees, often of sawlog size, left in a stand after thinning to grow until the next harvest. Also called leave trees.

residuals (residual trees). Trees left standing after harvesting.

rot. Wood in a state of decay

S

salvage. To harvest trees that are dead or are in poor condition but can still yield a forest product.

sample. A small collection from some larger population.

sample tree. A representative or average-size tree, chosen for detailed measurement of condition, size, growth, or quality.

sanitation cut. The removal of dead, damaged, or susceptible trees done primarily to prevent the spread of pests or pathogens and so promote forest hygiene.

sapling. A young tree of small diameter, typically 1 to 9 cm DBH.

sapwood. The light-coloured wood that appears on the outer portion of a cross section of a tree. Contains living cells; serves to conduct water and minerals to the crown.

sawlog. A log large enough to be sawn into lumber.

seed tree.

- A tree that produces seed.
- Trees reserved in a harvest operation to supply seed.

selection silvicultural system. A periodic partial-cutting, controlled by basal area, using vigour and risk characteristics to determine individual tree selection. An uneven-aged silvicultural system.

selective cutting. The cutting of individual selected trees. There are generally few if any control measures. Also known as high-grading. Not to be confused with the selection silvicultural system.

self-pruning. The natural death and fall of branches from live trees due to causes such as light and food deficiencies, decay, insect attack, snow and ice; also called natural pruning.

shade tolerance. The capacity of a tree or plant species to develop and grow in the shade of and in competition with other trees or plants.

shelterwood. The cutting method that describes the silvicultural system in which, in order to provide a source of seed and/or protection for regeneration, the old crop (the shelterwood) is removed in two or more successive shelterwood cuttings. The first cutting is ordinarily the seed cutting, though it may be preceded by a preparatory cutting and the last is the final cutting. Any intervening cutting is termed removal cutting. An even-aged stand results.

shelterwood silvicultural system. An even-aged silvicultural system where in order to provide a source of seed and/or protection for regeneration, the old crop is removed in two or more successive cuttings:

- **Group Shelterwood System:** Patches of advanced regeneration arising from thinnings or from natural disturbances, commonly developed in even-aged stands. Where this condition is prominent, shelterwood cuttings can be made specifically in relation to the requirements of each group of advanced regeneration. These clumps of regeneration are enlarged by the removal of all or most of the trees above them and initiating preparatory or seeding cuttings around them. The holes created in the canopy are gradually enlarged to keep pace with the establishment of reproduction.
- **Irregular Shelterwood System:** Harvest cutting in which opening of canopy is irregular and gradual; generally in groups, with the final cutting often is strips; regeneration natural; regeneration interval long, often up to half the rotation and the resultant crop considerably uneven-aged and irregular.
- **Strip Shelterwood System:** A shelterwood system in which regeneration cuttings are carried out on fairly wide strips, generally against the prevailing winds and progress rapidly; regeneration is mainly natural, regeneration interval short and resultant crop fairly even-aged and regular.
- **Uniform Shelterwood System:** A shelterwood system in which the canopy is opened fairly evenly throughout the regeneration area; regeneration is mainly natural, though it may be supplemented artificially; regeneration interval fairly short and resultant crop more or less even-aged and regular.

silvics. A knowledge of the nature of forests and forest trees, how they grow, reproduce and respond to changes in their environment.

silvicultural system. A process whereby forests are tended, harvested and replaced, resulting in a forest of distinctive form. Systems are classified according to the method of carrying out the fellings that remove the mature crop with a view to regeneration and according to the type of forest thereby produced.

silviculture. The art and science of producing and tending a forest; the theory and practice of controlling forest establishment, composition, growth and quality of forests to achieve the objectives of management.

silviculture prescription. A site-specific operational plan that describes the forest management objectives for an area. It prescribes the methods for harvesting the existing forest stand and a series of silviculture treatments that will be carried out to establish a free growing stand in a manner that accommodates other resource values as identified.

single tree selection. The cutting method that describes the silvicultural system in which trees are removed individually, here and there, each year over an entire forest or stand. The resultant stand usually regenerates naturally and becomes all-aged. *see selection silvicultural system.*

site. An area of land, especially with reference to its capacity to produce vegetation as a function of environmental factors (climate, soil, biology, etc.).

site class. A grouping of similar site indexes that indicates relative productivity. The common system in Ontario is Site Class X, 1, 2, 3, 4 (PFR).

slash.

- Tree tops, branches, bark and other debris, left after a forest operation; or
- The process of cutting down undesirable vegetation.

snag. A standing, dead tree or a standing section of the stem of a tree broken off at the height of six metres or more. If less than six metres, it is properly termed a stub.

softwood. One of the botanical group of trees that generally have needle or scale-like leaves-the conifers. Also the wood produced by such trees, regardless of texture or density.

species (of trees). Trees having very similar genetic makeup, so that they freely interbreed and have common characteristics. In common language, a 'kind' or 'variety.' Each species is identified by a scientific name that consists of a genus portion and then a species portion (*Pinus strobus*, white pine).

species composition. The percentage of each recognized tree species comprising the forest type based upon the gross volume, the relative number of stems per hectare or basal area.

sprout.

- Any shoot arising from a plant; or
- A young tree developed directly from the base, stump, or root of another tree. Relatively common among hardwoods.

squirrel's nest. A mass of branches and leaves similar in appearance to a stick nest, but usually less organized in appearance. The presence of old leaves is a good indicator.

stand. An aggregation of trees occupying a specific area and uniform enough in composition (species), age and arrangement to be distinguishable from the forest on adjoining areas.

stand density. The number of trees usually expressed on a per hectare basis.

stand structure. The distribution and representation of age and/or size classes and of crown and other tree classes within a stand.

stand table. A summary table showing the number of trees per unit area by species and diameter classes, for a stand or type. The data may also be presented in the form of a frequency distribution of diameter classes.

stem. The trunk of a tree.

stick nest. A platform of sticks (twigs up to small branches) constructed by some bird species for nesting.

stocking.

- A measure of the proportion of the area in a stand actually occupied by trees expressed in terms of stocked quadrants or per cent of canopy closure. Usually expressed as trees per hectare or some relative measure (well stocked, fully stocked, overstocked, understocked).
- A qualitative expression of the adequacy of tree cover on an area, in terms of crown closure, number of trees, basal area or volume, in relation to a pre-established norm.
 - **fully stocked:** Productive forest land stocked with trees of a merchantable species. These trees by number and distribution or by average DBH, basal area, or volume are such that at rotation age they will produce a timber stand that occupies the potentially productive ground. The stocking, number of trees and distribution required to achieve this will usually be determined from yield curves. Sometimes called *normally stocked*.
 - **over stocked:** Productive forest land stocked with more trees of merchantable species than normal or full stocking would require. Growth is in some respect retarded and the full number of trees will not reach rotation age according to an appropriate yield and stock tables for the particular site and species.

stock table. A summary table showing the volume of trees per unit area by species and diameter classes, for a stand or type.

sucker.

- A sprout from the lower portion of a stem, especially from the root.
- A shoot or tree originating from adventitious buds on roots.

sunscald. Death of cambial tissue on one side of a tree, caused by exposure to direct sunlight.

supercanopy tree. A living tree that sticks up well above the main canopy of a forest stand.

T

thinning. Cutting in an immature stand to increase the growth rate of the leave trees. The goal is to foster quality growth, improve composition, promote sanitation and recover and use material that would otherwise be lost to mortality. Thinning does not generally increase per-hectare volume growth, but it can increase lumber yield.

thinning from above. A thinning that favours the most promising (not necessarily the dominant) stems, with due regard to even distribution over the stand, by removing those trees that interfere with them. Also known as *crown thinning*.

thinning from below. A thinning that favours the dominants or selected dominants more or less evenly distributed over the stand by removing a varying proportion of the other trees. Also known as *low thinning*.

- *types of thinning:*

- **low thinning:** The removal of trees from the lower crown classes in a stand. Also known as *thinning from below*.
- **crown thinning:** The removal of trees from the middle and upper crown classes in a stand, to favour the most promising trees of these classes. Also known as *thinning from above*.
- **selection thinning:** Removal of dominant trees to benefit trees in lower crown classes.
- **free thinning:** Removal of trees to benefit best trees, regardless of crown class.

mechanical thinning: Removal of trees based totally on their spacing or arrangement. Also known as *row thinning*.

timber. A term loosely applied to forest stands or their products; often applied to wood in forms suitable for heavy construction.

tolerance. The capacity of a tree or plant to develop and grow in the shade of (and in competition with) other trees or plants; a general term for the relative ability of a species to survive a deficiency of an essential growth requirement (light, moisture, nutrient supply).

U

UGS - unacceptable growing stock. These trees do not have the potential to make salable sawtimber products in the future, but may have merchantable products now. They may be high risk trees—trees with disease, damage, or dieback that threatens their survival—or trees of such poor form that they just have to be removed regardless of the effect that removal will have on stand structure and species composition.

understory. That portion of the trees or other vegetation in a forest stand below the canopy.

uneven-aged. Applied to a stand in which there is considerable difference in the age of the trees and in which three or more age classes are represented.

uneven-aged management. The application of a combination of actions needed to simultaneously maintain continuous high-forest cover, recurring regeneration of desirable species and the orderly growth and development of trees through a range of diameter or age classes. Cutting methods that develop and maintain uneven-aged stands are single tree selection and group selection.

W

white-face basal wound. Wound with a dry, casehardened surface usually associated with localized stain and very limited decay, if any. They are neither ground contact or cupped to retain water.

widowmaker. Any limb, top, leaning tree, or other material in the forest that is in danger of falling to the ground without warning, creating a safety hazard. Often applied to limbs that get lodged in the crowns of other trees during a logging operation.

wilderness area. A rather large, generally inaccessible area left in its natural state and available for recreation experiences. It is void of development except for those trails, sites and similar conditions made by previous wilderness users.

wildlife. Undomesticated vertebrate animals, except fish, considered collectively.

wildlife trees. A wildlife tree is a standing live or dead tree with special characteristics that provide valuable habitat for the conservation or enhancement of wildlife. Characteristics include age, diameter and height for the site, current use by wildlife, species value, location and relative scarcity.

windthrow. Uprooting or breakage of trees caused by strong winds.

X

xylem. A complex tissue in the vascular system of higher plants that consists of vessels, tracheids, or both together with wood fibres and parenchyma cells,

functions chiefly in conduction but also in support and storage and typically constitutes the woody element.

Y

yield.

- The harvest, actual or estimated, howsoever measured, over a given period of time.
- Growth or increment accumulated by trees at specified ages expressed by volume or weight to defined merchantability standards.

Appendix F

8.6 Other Contacts

Ontario Ministry of Natural Resources:

Natural Resources Information Centre

300 Water Street

P. O. Box 7000

Peterborough, ON

K9J 8M5

English (416) 314-2000

French (416) 314-1665

OMNR Kemptville

Postal Bag 2002

Concession Road

K0G 1J0

(613) 258-8204

OMNR Kingston

Ontario Government Building

Beachgrove Complex

798 King Street N.

K7L 5S8

(613) 531-5700

OMNR Pembroke

Riverside Drive

Box 220

K8A 6X4

(613) 732-3661

OMNR Tweed

Postal Bag 70

Old Troy Road

K0K 3J0

(613) 478-2330

Ontario Ministry of Agriculture Food and Rural Affairs:

Kemptville Field Office

P. O. Box 2004

ORC Building

Kemptville, ON

K0G 1J0

(613) 258-8295

LandOwner Resource Centre

P. O. Box 599
5524 Dickinson Street
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Fax: (613) 692-2806

Ontario Woodlot and Sawmill Operators Association

275 County Rd. 44
RR #4
Kemptville, Ontario
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Tel: (613) 258-0110
Fax: (613) 258-0207

Eastern Ontario Model Forest

P. O. Box 2111
Kemptville, ON
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Federation of Ontario Naturalists

355 Lesmill Road,
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Ontario Forestry Association

Suite 502-150 Consumers Road
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Ontario Professional Foresters Association

Suite 102
27 West Beaver Creek Road
Richmond Hill, ON
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Ontario Maple Syrup Producers Association

RR# 6

Strathroy, ON

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Canadian Forestry Service

Great Lakes Forest Research Centre

1219 Queen Street East

Sault Ste. Marie, ON

Tel: (705) 949-9461

USDA Forest Service

P. O. Box 640

Durham, NH

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Tel: (603) 868-7699